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CAMPBELL'S

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Soil Culture Manual.

Price, 40 cents.

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1902

Soil Culture Manual

Explains how the Rain Waters are Stored and Conserved in the Soil; how Moisture Moves in the Soil by Capillary Attraction, Percolation and Evaporation, and how these conditions may be regulated by cultivation.

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H. W. CAMPBELL,
Author and Publisher,
Holdrege, Nebraska,
U. S. A.

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West-Land Glory and Greeting.

In its new-born days—years long since gone by—
Before the people of our land
Had learned to grapple with strong hand
Soil culture problems; hearts were sore,
And poverty hung 'round the door.
But times have changed! And nevermore
From west throughout, will hear the cry
Of woe or want. Plain the reason why!

The east came west, in years gone by,
With glad refrain the west-world rings.
Each year's returns rich profit brings,
And woe long time ago took wings.
Our west-land bloometh as the rose,
Our happy youth-folk, best that grows!
Prosperity hath come—that's why
The west-land doth the world defy.

NELLIE HAWKS.

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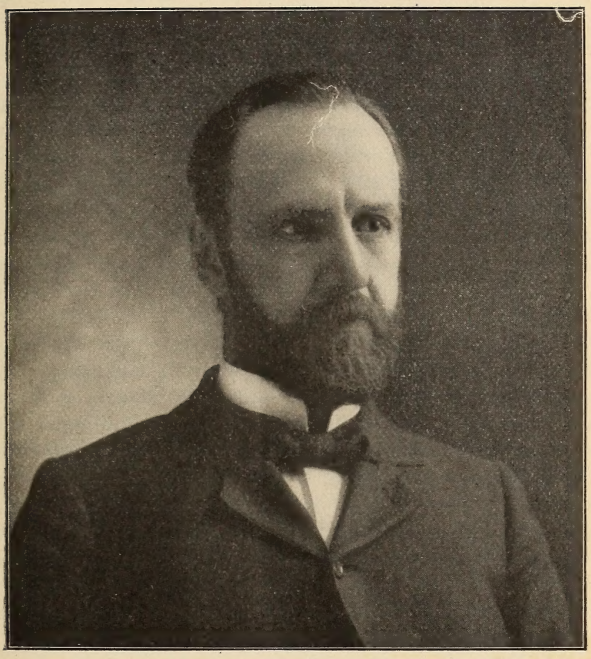


Yours for better Crops and better Homes,

H. W. CAMPBELL.

INTRODUCTION.

Having been convinced by years of constant labor in the field, and practical results attained by soil culture experiments, that the average farm crops throughout the west are not what they might be if proper cultivation was applied; and realizing what it would signify to the great Semi-Arid Belt if every farmer in that section could grasp the fundamental principles involved in the science of soil culture, which are really plain and simple, and put them into practical use, I have been prompted to prepare the matter contained in these pages.

I desire, if it may be possible for me to do so, to in some measure supply the rapidly growing demand for a broader and more comprehensive knowledge of soil culture and the storage and conservation of the available soil waters for the increase of crops, and the greater profit thereby to the farmer; also to aid and encourage public sentiment in favor of farm life and ideal farm homes.

I believe one of the important sentiments as respects home life on the farm is the abolishment of the "Bonanza" farm idea. The small farmer has given character to agriculture everywhere and at all times. He cultivates a smaller area, produces a greater diversity of crops and practices a more intensive system of cultivation. His farm is his home, which he wishes constantly to improve by the growing of trees, fruit, flowers and shrubs. He has a better conception of economy; his wife and children are happier and better contented; in short, it is upon the comparatively small farms that many a bright young man and woman have found opportunities to develop a capacity for the higher and nobler duties and service of life.

Make the farm as comfortable and attractive as possible, and the children will love it as their home, and will feel a deeper respect for their parents, and will more fully appreciate nature in all her fruitfulness and glory.

The "Bonanza," or large scale system of farming, reverses all this; for in that case the home is not a home, but merely a place where the family stay. It is seldom beautified by trees or flowers; it is unattractive, and the very atmosphere of such a place will depress the mind of the true agriculturalist. Such a system is always barren of what is pleasing to the eye, and to the mind, and is generally a system of soil butchery.

Under the "Bonanza" system, two acres are required to do less than one should do, and, as a rule, everything is in a state of congestion; strenuous activity abounds with, generally, unsatisfactory results. Little time

is given to moral, mental, or physical culture, to the school or the church, or the growth of religious sentiment in the community, and to the broader educational work, such as the "Farmers' Institute;" and the general effect of this stunted condition is to retard the development and improvement of agriculture and the people who follow it.

It is not intended to lay down in this volume a code of imperative rules to govern the farmer in every act of soil culture, but rather by explanatory illustrations to present as clearly and plainly as possible the fundamental principles which govern the movement of moisture in the soil, the development of plant life, and the quantity and quality of the crop. After these general principles have been grasped and understood, the necessary labor in detail required to make agriculture profitable becomes clear and easy to anyone who will give these pages a careful perusal.

There cannot be laid down any rule by which to be guided in the cultivation of the soil under all conditions. Soil that is too wet, naturally, must be drained, while soil that is too dry by reason of insufficient rainfall, or by reason of the fact that the rainfall in any section is not distributed seasonably, is unfavorable to the production of any crops, but in the great semi-arid area of our western country we believe a general rule may be applied, and if followed diligently the resulting storage and conservation of the natural rainfall in the soil will produce, in average years, as good crops of cereals, and of all the vegetables that are commonly grown, as can be produced in the humid central portions of the United States.

Storage and conservation of the rain waters is the basis of all this fruitful production. Has the reader not observed instances where a heavy snow drift has, by reason of some obstruction in the wind's course, lodged in a field, and where the snow was drifted the crop in the following summer was better? The usual conclusion has been that the snow drift protected the grain sown in the soil like a blanket, and the greater yield the following season was attributed to such protection; but this is an error. The reason of a greater crop on the ground so covered with the snow was that the snow melted gradually in the spring time and percolated into the soil at a much greater depth, and was stored, as in a reservoir, and, later, when the hot period and drought of summer came, supplied the roots of the plants with moisture and kept the plants growing when the plants in other parts of the field not so supplied were checked, and perhaps withered.

By that almost unexplainable movement of the moisture in the soil upwards towards the surface, under a natural law which is called capillary attraction, the roots of the growing plants on the spot where the snow had drifted were supplied from the reservoir of water below, which had come down into the lower strata of the soil as the snow in the drift had melted.

We have endeavored to show that by storage and conservation of the rain waters in this way, so as to save them for plant nourishment and growth in the summer period, like results and yields may be obtained on large fields, as have been observed on small patches of ground that happened to be covered by snow drifts. It follows, then, that the greater amount of water we can store in the soil previous to the planting of the crops, as well as during their growth, and the greater care we use in the cultivation of the surface of the ground, so as to retain and economize the moisture so conserved, the greater must be the yield at harvest time.

In connection with this fact there is another of no less importance, viz: the soil should be prepared as perfectly as possible to insure a prolific growth of roots. It is not uncommon that a single hour's extreme condition of the soil, as respects rapid evaporation, will reduce the crop one-half. If we can store and conserve in the soil a sufficient quantity of the natural rain waters and make them available during the growing season, and have coupled with the moisture a sufficient growth of roots to sustain and nourish the plants, a good crop is sure to be realized.

We are well aware it is difficult to explain what is the exactly proper physical condition of the soil for the best results in growing crops. It is important to learn how to apply the most economical mechanical work to secure such results. There are many little things and minor points to be done and observed that have a direct influence and effect in securing this condition, and many more that bear on the question as to how to maintain this good condition of the soil during the growing season, that have not been considered in the past, but which are vital and necessary to the best possible crop yields.

With these considerations fully in mind, we have tried, in the following pages, to be clear in our statements and illustrations respecting all these little points and duties we owe to the cultivation of the soil, and to make plain to the reader an explanation of our past work and the results of our years of experience and experiments in the semi-arid west, a section which at a time, not far distant, we believe will be made by our system of soil culture, to yield an abundance, and will be the abode of millions of new settlers who will found homes there that shall be blessed with peace and plenty.

THE SEMI-ARID BELT.

ITS GREAT RESOURCES AND ADVANTAGES.

That vast country known as the Semi-Arid Belt, extending from Canada, on the north, well into Texas, and from the Rocky Mountains to the Missouri River, and across that river, easterly, through the Dakotas and into western Minnesota, began to receive its first settlement in considerable numbers about twenty-five years ago.

The experiences of the people who have lived in that country of great prairies during this period have been varied in the extreme. They have had years of partial and years of total failures, and interspersed along with occasional years of good crops. Alternate hope and despair have filled the settlers' minds. Had it not been for the cows and chickens and the small garden with the windmill as an irrigator, and the stockraising industry, much of that great section would long ago have been largely depopulated and abandoned as an agricultural country.

Up to 1894 very little attention had been given to the question as to how the soil of that section might be treated to insure crops, and the old method of farming was pursued, with the usually attendant disappointment.

The press drill and other tools were introduced as having the required merits for overcoming the drought; irrigation was talked of and in some instances tried; summer fallowing was tried without any material change in crop results.

The "Rain Maker" came, and with boastful confidence in his powers attempted to perform miracles, and failed.

Trees and orchards by the thousands were planted all over that country, only to be cut down by the hot winds and the long periods of mid-summer drought. During this time agriculturical colleges were established in these states, but the conditions as respects both the climate and soil formations were all new, and it was first necessary for the professors to study and experiment to ascertain what might be done and how to do it to overcome what appeared to be insurmountable difficulties.

Not until the subject of the storage and conservation of the natural rainfall in the soil began to be comprehended did any real light or hope for the successful solution of this hard problem come to us.

The development of our investigations, pursued along this line of thought and theory, has at last brought us to the one significant conclusion, namely, that the storage and conservation of the rainfall in the soil by our method of cultivation is the only means of saving that great section and making it bloom and prosper.

THE POMEROY MODEL FARM.

ITS MISSION.

The Pomeroy Model Farm was established at Hill City, in Graham County, Kansas, in March, 1900, for the sole purpose of demonstrating what might be accomplished in a section of the Semi-Arid Belt under the so-called "Campbell Method of Soil Culture." For three or four years considerable effort had been made by the railroads in the Dakotas, Nebraska, and Kansas to encourage better cultivation along their lines by establishing what was then called Experimental Farms. Arrangements were made with individual farmers in various localities, sixteen in all, in 1896, and upwards of forty in 1897, a much less number in 1898, and in the fall of that year we refused to proceed further on this plan, as a general supervision of all this work was left to us. From the work done a fair amount of good results were secured so far as the public at large were concerned; but, personally, we obtained much valuable information and made a great deal of progress in our discoveries in soil culture.

In the first place it seemed entirely out of the question with our occasional visits for the average operator of these experimental farms to grasp the principles and rules of the system. It was not uncommon for us to find the man in charge very busy with his own private work, consequently his mind and attention were not given to the necessary points in the work on the experimental plat. He was in a hurry, and sometimes seemed a little anxious for us to move on.

In the next place, there was an expectation of too much from the first year's cultivation. While the great amount of work done created general interest, and considerable curiosity as to what might result from it, the special interest was not what it would have been had the work been more thorough and confined to a less number of stations.

At the Pomeroy Model Farm no other kind of work has been attempted except to grow crops, trees, shrubbery, and orchards under the Campbell method, and due attention has been given to the proper preparation of the soil, and the storing and conserving in the soil the natural rainfall. One of the important discoveries we are now making and are working out, and happily with great satisfaction and remarkable results, is the effect and value of summer cultivation, which aids so materially to store and conserve the rain waters during the entire season, preparing the seed bed for the sowing of grain in the fall or planting in the following spring. So far, only winter wheat has been grown on soil thus treated, and the yield obtained in 1901 was fully three hundred per cent. more than the yield of

adjoining farms cultivated by the usual method of farming. In 1902, other crops will be grown on ground thus treated.

The general plan of our cultivation on the Pomeroy Model Farm is exactly as explained in the different chapters of this volume. Many new and important experiments will be worked out there during the coming season, which we are sure will add greatly to the discoveries and knowledge already made and obtained on this invaluable subject.

The illustrations shown in cuts Nos. 14, 15 and 16 very clearly demonstrate the value of our plan of growing and developing trees. We have laid out with considerable care a part of the farm for buildings, setting apart a parcel of land for a garden and small fruits, with the orchard in the rear; the object being to create here an ideal farm home.

To our mind, there is nothing that means more to all of us as a neighborhood, county, state or nation than the increasing improvement of our farm homes, and making them attractive and pleasant. The influences that go out from such homes for good are felt in many ways. In the attractiveness of the farm home for the wife and children, there is found the primal creation and nurture of the most valuable mental gifts, and the dearest affections. In the orchards, and the shade trees, and in the flowers and shrubs that adorn a home are to be found the objects to which the heart is attached with more tenacity and tenderness than the domain of lands

In our experience thus far, it is clear that in five years time one may grow up shade and ornamental trees, as well as fruit trees, to such an extent as to yield beauty, comfort and profit, which largely embody all the factors that are required to make the ideal farm home. Consider for a moment that the bleak prairie may be transformed into ideal farm homes in the short space of five years. Nothing can add more to the wealth of the country and the value of our farm lands than such improvements created generally over our western prairies. We have in mind an instance in the early settlement of Eastern Nebraska which was related to us by one of the parties concerned, that illustrates the love of the average man for trees. A man from Ohio with a reasonable amount of means had come to Nebraska to buy a farm. He was offered one with good buildings and other improvements, excepting there was no orchard or shade trees. The price asked was $15.00 per acre, but he purchased the farm adjoining, on which there were no better buildings, and the land was of precisely the same character, but with an orchard of five acres and a liberal number of shade and ornamental trees around the buildings of about eight years' growth, and the purchaser paid just twice the price of the other farm—paying, as you observe, as much for the fruit and shade trees as he paid for the land and all the other improvements. This may have been an extreme case, but it shows quite clearly how dominant is the love in all of us for such adornments of the home as nature gives us in beautiful trees.

In our small towns on the prairies we find, occasionally, homes with a liberal number of trees around them, all in healthy and thrifty condition, having been carefully pruned, showing symetrical and uniform shape, and greatly attractive. Such homes are envied by the passers by, and comments are frequent with reference to their beauty and attractiveness, and a very common remark is, "I would like to have such a home."

Outside of the pleasure and real comfort to be derived from numerous shade and ornamental trees, there is also much value in them in the protection of our fields and crops. It has long been asserted by scientists that the growing of trees on the bare prairies will increase the rainfall. If there is any reliable evidence of this to be gathered by common observation, we must admit there is truthfulness in this theory, for in the eastern portions of Nebraska and Kansas the statements of the older settlers verify it.

In the early days, when the prairies of eastern Nebraska and Kansas were as treeless as is the extreme western portion of these states today, failure by drought was not uncommon, while now, with almost every section of land bordered and defined by trees, and with groves and woodlands everywhere, the reverse is quite true. The effect of trees in lifting the hot south winds from the surface and carrying them over the growing crops is perceptible; especially is this noted where there is a considerable growth of trees, and a crop planted on the north side of the grove. It should therefore go without further argument that the planting of trees is important, even in the more humid portions of our country, but especially important and valuable in the semi-arid sections.

That trees can be grown in the semi-arid belt by the simple application of the "Campbell Method," there is no further question. Evidence is now too conclusive for any one to deny this assertion. Not only is this true, but with careful attention trees may be made to grow as rapidly as in any section of the east or middle west, and conclusive evidence of this may be seen now on the Pomeroy Model Farm.

One of the principal objects for which the Pomeroy Model Farm was established was to present a practical illustration and demonstration, not only to show how easily and quickly trees may be grown and orchards brought to a bearing condition, but how inexpensively all this can be done. The prevailing notion that the cost of growing an orchard, or lines of shade trees around the farm buildings, is large is very erroneous. It takes but very little time and expense if the farmer but understands and will practice the right method of doing it. It is not difficult at all, and only requires comparatively little labor to accomplish surprising results. In a subsequent chapter, entitled "Growing Trees," we have gone into details of our method quite extensively. The further and principal object of the Pomeroy Model Farm is to demonstrate that good crops may be grown each and every year by that proper cultivation which will store and con-

serve the rain waters. Also, to show that the necessary work is very simple and easy, and not at all expensive. Many farmers, who have read or heard something of the "Campbell Method," stand in their own light and continue to lose crops by presuming that this new method of cultivation is too expensive. The additional labor required is nothing compared to the difference between a forty-bushel and an eight-bushel crop.

The expense per acre of operating the Pomeroy Model Farm for the year 1901 was $5.48. This includes all cash paid out for labor, feed for teams, and six per cent. interest on $20.00 per acre, the estimated valuation of the land, and ten per cent. on the total valuation of teams and tools. In this computation there is included the cost of all the work done on the orchard, which contains ten acres. Our figures are high, and we have made them so because no work was done of any kind or nature on the farm that was not paid for at a good price. Those interested in these particular topics should watch closely the yields of the crops on this farm in 1902 and compute the profit of farming by our method.

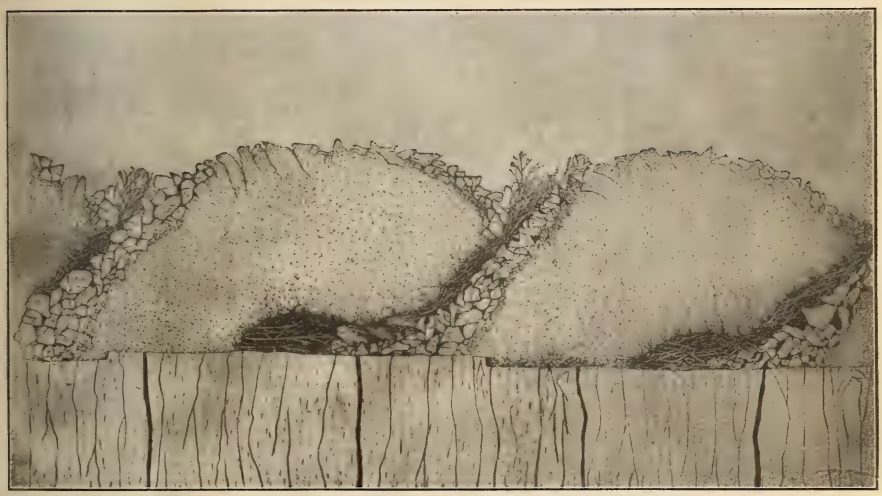
It will pay any man to visit this farm in June next, even though he lives hundreds of miles away, for he will find there a series of glad surprises, and he will, better than all else, find that "seeing is believing," and he will return home and, we believe, begin at once to cultivate the soil as we cultivate it on the "Model Farm" in Graham County, Kansas.

PLOWING.

In outlining our general suggestions for securing the best possible crop results throughout this great plains country, we must of course begin with the preparation of the ground. Owing to the fact that in the settled portions the average farmer has already a sufficient area of ground under cultivation, we will start out with the preparation of ground that has been in crop the previous year. The first and all important work is the double discing of this ground in early spring, beginning as soon as the frost is out a fair depth and the surface sufficiently dry to allow of discing without having the soil adhere to the disc too much. It is not uncommon to see farmers double disc by first going over the ground one way and then cross disc it. This results in a series of ridges and trenches, leaving the surface very uneven. The trenches exposing solid soil to the surface allow of much evaporation. The proper manner of double discing is to lap half, which leaves the surface smooth and thoroughly pulverized. In the lapping of the half of the disc the last time over, the last discs revolve at right angles with the discs that precede.

It is hard to put too much stress upon this important point. Bearing in mind that the all important element for the successful growth of our crops is water, we must lose no opportunity of conserving and storing the water from the earliest part of the spring to late in the fall. By the double discing explained in the previous paragraph, we have done two very important things in the storing and conserving of water. First, the pulverizing of the surface forms a dry, loose mulch of soil which prevents evaporation.

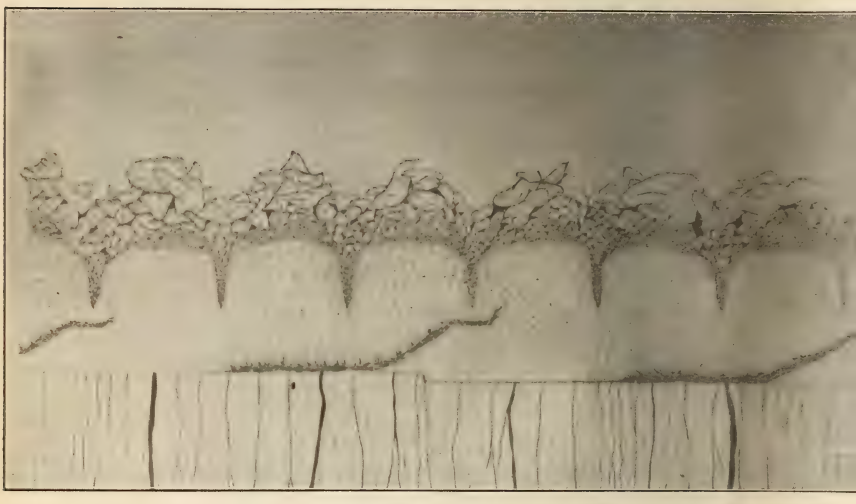
Second, it leaves the surface in the best possible condition for rapid downward percolation of the melted snows and rains which may fall later.



Cut No. 1.

Evaporation and percolation are more fully explained in chapters to follow. After thoroughly pulverizing the surface to stop the evaporation we can then do our plowing a little later, regardless of the climatic conditions which may exist, and we shall find the soil in a moist condition. It is very important that much care and attention be given to the condition of the ground at the time the plowing is done. Land should not be plowed when in bad physical condition, even though the surface soil contains more plant nourishment than the sub-surface does, for good physical conditions are quite as necessary, perhaps more necessary, than an abundance of available plant food. This cannot be obtained in the seed and root bed unless careful attention is given to these points.

In cut No. 1, we illustrate the common condition of ordinary plowed fields. Note carefully the appearance underneath the portion of the furrow that has been thrown over by the mouldboard on to the side of the next furrow. Here is the stubble, weeds, and clods that have rolled from the next furrow, while right at the point where the furrow is tipped over the soil is firm from the bottom up. The usual manner of further fitting this ground is by the use of the harrow. This has a tendency to level, and, if shallow plowed, to work the ground down fairly well at the bottom of the plowing, but in deep plowing, of five or more inches, the harrow has but little effect upon these cavities underneath. This is a very serious propo-



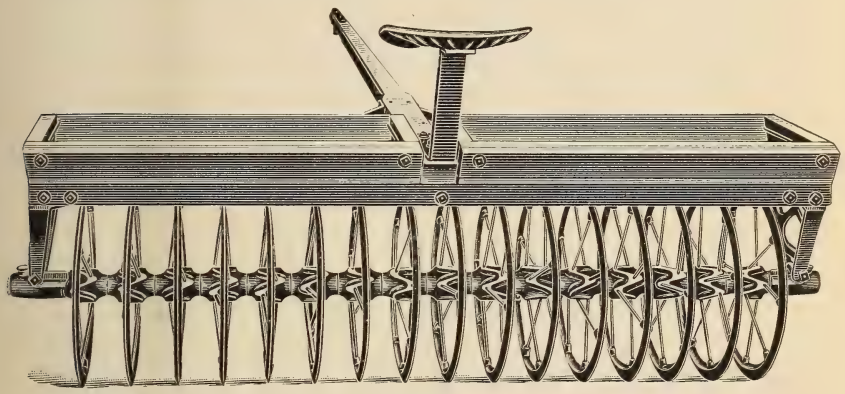
Cut No. 2.

sition, and it is the source of many bad conditions, which have a direct effect upon the final yield of the crops. First of all, it cuts off the seed or root bed from the sub-soil below; thus preventing the movement of any moisture from the sub-soil up into the root bed. It also forms air spaces or cavities where a volume of air may exist, which aids in drying out the soil immediately adjacent. It also prevents the lateral roots and feeders from extending and permeating this portion of the soil, thus leaving a large per cent. of our surface soil in a condition not at all beneficial to the growing crop.

In cut No. 2, we show the cross-section of the same two furrows shown in cut No. 1. Here the cavities and loose condition of the soil at

the bottom of the furrow have all been obliterated by the use of the subsurface packer, which is illustrated in cut No. 3. These sharp, wedge-faced wheels have both a downward and lateral pressure against the soil in the spaces between them. The soil is moved by the packer in such a manner as to form a firm and evenly compacted stratum. After the packer has been used, by the use of the ordinary smoothing harrow, or the Acme harrow (so-called), the surface is pulverized and made fine, and part of the lower portion of the stratum mentioned and shown in cut No. 2 is made firm, forming a perfect seed bed, while the lower portion of the same stratum or furrow slice may be properly termed the root bed.

With this general explanation, let us return to the question of plowing. With the varied experiences of the average farmer throughout the semi-arid west there has arisen a great variety of ideas with reference to



Cut No. 3.

depths of plowing, and as to whether it is advisable to even plow more than once in a space of two or three years. Each farmer believing he has conceived a very plausible reason why he should plow three or five inches, or why he should not plow at all. Now, I fully appreciate the honesty and good intentions of the farmer, but the reason there is such a great variety of opinion is because they do not grasp the importance of a certain physical condition of the soil, one that is favorable to holding the largest amount of moisture to the square inch, one that is favorable to the most rapid movement of moisture by capillary attraction, and one that is favorable to the most prolific growth and development of the lateral roots with their thousands of little feeders. This condition cannot be secured at its best and the largest productive results obtained without thoroughly plowing, pulverizing and compacting the soil each and every year. The point gained by the plowing at a sufficient depth to stir the soil which will later

contain the major part of the feeding roots is that of increasing the water holding capacity of the soil. The more completely we can separate one particle from another, reducing the soil to the greatest fineness, then thoroughly firming it, the greater is its water holding capacity. Water is not held in the soil in cavities or spaces, but is held in the form of films or coverings around each diminutive soil particle, consequently the greater number of small particles of soil we have the greater the amount of water held. We can illustrate by a cube one inch square; this contains six square inches of surface. Cut this cube into eight squares one-half inch square and we have twelve square inches of surface. Now, cutting each half-inch cube into eight one-fourth inch squares we have twenty-four square inches of surface, thereby increasing the water holding capacity three hundred per cent. The tendency of all soil that is left for one or more years without being plowed or pulverized, is to form into larger soil grains. By the little particles adhering to each other, cemented or attached by the salts, magnesias and alkalies that are dissolved by the water as it percolates down and then moves upward, holding these properties in solution, and as the moisture passes off by evaporation, these salts and alkalies fill the little spaces, and the smaller particles form larger soil grains and thus decrease the water holding capacity.

There is still another important point, and that is the thorough circulation of air in the soil. Air, like water, is an important element in the soil, and, like water, it must be finely and evenly distributed.

In further discussing the question of what is the proper physical condition of the soil when plowing is done, we would call your attention to the furrow as it is turned over by the plow when the soil is simply moist—not very wet nor very dry. How nicely each little particle of soil seems to separate, one from the other, when, if too dry, a cloddy condition is observed; and the same is true when the soil is too wet. We should try to secure the most uniform, fine condition of our soil for the threefold purpose that it may contain more water, that moisture may move more rapidly through it, and that there may be a more prolific growth of roots. By close observation and careful attention to these important points we may secure a crop result fully one hundred per cent. greater than we could obtain if these items were disregarded.

The proper depth of plowing must be governed very largely by the kind of tools you have for after-fitting and care and attention which you give the work. In some localities the sub-surface packer is quite commonly used. If you have one of these tools it is advisable to plow at least six or seven inches deep, following the plow closely with the sub-surface packer; provided, however, the ground has been previously disced so as to retain the moisture, when you will be able to completely obliterate all the cavities, leaving the under portion of the furrow slice thoroughly fine and firm as shown in cut No. 2. If you have no sub-surface packer I

would not advise plowing over four or five inches deep, and use the common harrow with teeth slightly slanting and weighted; the object being to pulverize and firm and compact the under portion of the furrow. These observations are very important. Much care and attention should be given to the furrow slices that they may be even in width and depth, so that when you go over the ground with your packer or harrow there may be no soil spaces left loose and porous. It is hardly possible for the average farmer to conceive the great importance of thoroughly fining and firming the entire plowed portion. In the ordinary conditions as found at the bottom of furrows in plowing left without any further work until it has all dried out, shown in cut No. 1, fully one-third of the soil contributes no nourishment whatever to the growth or production of the crop. By adding a little extra pains and labor that one-third of non-productive soil may be put in condition to do its full share in making a larger and better crop. By closely following this rule you will greatly increase the quantity and quality of your crops of small grain.

There is no economy, but, on the other hand, great waste, in trying to economize or minimize the amount of labor required to thorougly prepare the soil for the sowing or planting of grain, for the work of thorough preparation is easily and quickly done, and when once done a successful harvest is assured.

SUB-SURFACE PACKING.

The belief used to be almost universal among farmers that firming the ground, as with the roller, or making firmer the soil in any way, increased its water-holding capacity. Firming the surface of the ground does, in fact, for the time increase the amount of water which may be held in the compacted portion, and it is therefore natural that this belief should have been general among farmers. Some lessons of vital importance may be learned upon this subject. The movement of the water in the soil under varying conditions of the soil and the surface should be well understood by every farmer. A discussion of the subject may not seem of interest to the average farmer, yet the well established facts in regard to this subject have great weight when carefully considered in connection with the preparation of the soil for crops and in determining the quantity and quality of all our crops.

Prof. F. H. King, of the State University of Wisconsin, undoubtedly one of the most learned men in soil physics we have in the west, if not in the country, has recently published a book entitled "The Soil," which

book should, by the way, be in the hands of every farmer. In treating the question of the effect of rolling on soil moisture, he says:

"When, however, the changes in the water contents of the surface four feet of soil which follow the use of a heavy roller are studied, it is found that we have here another case of the translocation of soil moisture; a case where by destroying the many large non-capillary pores in the soil, and bringing its grains more closely together, its water-lifting power is increased and to such an extent that often within twenty-four hours after rolling, the upper one or two feet beneath the firm ground have come to contain more moisture than similar and immediately adjacent land does at the same level, while the lower two feet have become dryer. Water has been lifted from the lower into the upper soil.

"In the table below will be seen the difference in the water contents of the soils which have been rolled and the immediately adjacent ones not so treated. These results are averages derived from 147 sets of samples:

"Surface 36 to 54 inches, unrolled, contained 19.43 per cent. of water.
Surface 36 to 54 inches, rolled, contained 18.72 per cent. of water.

Difference, .71 per cent. of water.

Surface 24 inches, unrolled, contained 19.85 per cent. of water.
Surface 24 inches, rolled, contained 19.49 per cent. of water.

Difference, .36

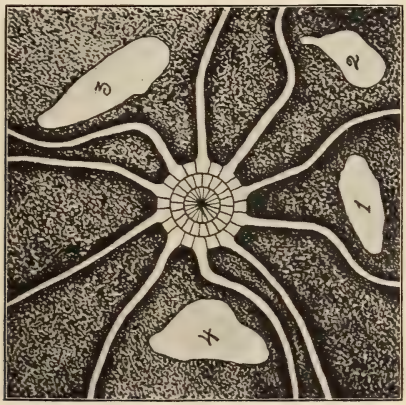
Surface 2 to 18 inches, unrolled, contained 15.64 per cent. of water.
Surface 2 to 18 inches, rolled, contained 15.85 per cent. of water.

Difference, x .21"

It is here seen that when samples of soil are taken at a depth exceeding two feet, the rolled ground as a whole is dryer than that not rolled, and that this difference is greater when the samples are taken at a depth of from three to four or more feet. The data presented also shows that the surface 2 to 18 inches of loose ground recently firmed contains more water than that which has not been so treated. This presents an important thought in regard to preparation of the soil. It is a matter we have carefully studied, and in all our experiment work we have observed that the statements of Prof. King have been verified fully; thus affording conclusive proof of the truth of all that we have said with reference to the sub-surface packing of the soil. When the extreme surface is packed the effect is to draw the moisture to the surface where it is lost by evaporation. By the sub-packing, as shown in cut No. 2, we have that firm stratum at the point where the roots mainly grow, and with our loose mulch on the surface we prevent the loss of our moisture by evaporation. In our chapter on percolation we explained at some length how the water

is gotten into the ground. After we have succeeded in storing a large quantity of water down in the soil to a depth of four, six, or possibly ten feet, the sub-packing, or thorough firming of the lower portion of the furrow slice, is very important, for when our crops reach the long, dry periods of extreme heat, such as was experienced in mid-summer of 1901, we are in position to feed the plant all the moisture it needs and thus prevent any material loss or damage. As shown by Prof. King, in 147 tests, the packing of the lower portion does materially aid the movement of moisture stored in the soil in its upward course to feed the roots.

We wish to impress upon the mind of the reader quite clearly the importance of doing everything possible to provide an ample amount of



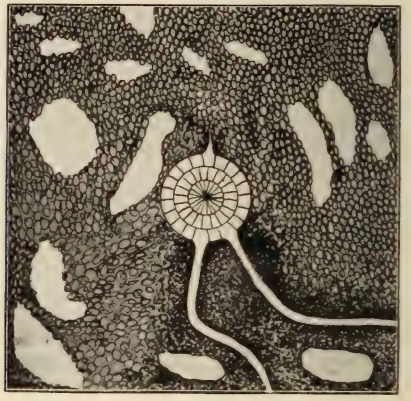
Cut No. 4.

available moisture at all times. When we reach a point in the extreme heated portion of the last afternoon prior to a heavy rain, where our supply of moisture is beginning to shorten, the fact that we have by this sub-surface packing been able to lift the water stored below a little faster may save our crop.

In cut No. 4, we represent the cross-section of a lateral or branch root very largely magnified. The little branches running out from the center represent the little hair roots, or feeders, which are often so small that they are scarcely perceptible to the naked eye. These little feeders are nothing more nor less than little tubes, or elongated cells. You will notice in the outer tier of cells each little feeder practically forms a part of the cell. Around this root are four white spots, which represent air spaces. They are, however, extremely small, not larger than the head of a pin; yet, small as they are, you notice how the little feeders turn away

from them. The soil where this root is located is represented to be very fine and firm. Under this condition we are able to get the greatest possible development of roots.

In cut No. 5, we represent a coarser or less compacted soil. Here the lateral root is only able to send out two little feeders. This condition is of much importance. We have examined roots many times and found them 3, 4, and 5 inches in length, with scarcely a hair root or feeder the entire distance. Then coming, possibly, to the compacted soil beneath a horse-foot track, we would find a complete net-work of little feeders running in every direction. There are two reasons for this greatly increased number of feeders in the compacted soil. One is the compact condition



Cut No. 5.

so favorable to the development of roots; the other is the greater amount of moisture contained, which, as we have shown by a quotation from Prof. King, is the result of an increased capillary attraction which has drawn moisture from below.

It is hardly possible to put too much stress upon the point of thorough pulverizing and compacting of the seed bed. Probably the strongest or most complete practical illustration was brought out at the Pomeroy Model Farm, at Hill City, Kansas, in the growth and development of the wheat sown in the fall of 1901. This ground had been prepared with the greatest possible care, having been plowed seven inches deep, with the soil in a moist condition, kept so by the discing and harrowing of the surface. When plowed, the plow was followed closely with the sub-surface packer, and the Acme harrow following closely the sub-surface packer. By endeavoring to do all the work when the soil was in proper condition.

we had secured a very favorable physical condition. At the time of seeding, October 8th, 9th, and 10th, there was a fine loose mulch on the surface two and one-half inches deep. The soil immediately beneath was very fine, firm, and moist. The wheat was put in with a shoe-drill, less than one-half bushel of seed to the acre, from one-half to one inch into this fine moist soil, just beneath the mulch. Germination and development was rapid. The fourth day, as regular as the days came after seeding, the little green spears could be seen the entire length of the row. On the seventh day these leaves measured from three to four inches high. Thus, in seven days, the hard, dry seeds had become moistened, burst their shells, and sent up the little stalks, and laterally the little rootlets, and had grown to a height of five or six inches from the seed. This is not all. On the 16th of November this wheat was taller and thicker than a field sown on the 16th of September, with one and one-quarter bushels of seed. This phenomenal difference is directly due to two conditions, namely: First, the very fine, firm seed and root bed; second, the loose surface, which prevented the evaporation.

We can cite many instances where the value of firming the under portion of the furrow slice has been shown to be very great. In the spring of 1899 a large amount of winter wheat in the semi-arid belt was found to have been killed. We drove over many fields that spring to investigate and study the cause as far as possible. One fact was invariably perceptible—where the soil was light and loose to a considerable depth the wheat was entirely dead. In the more compact portions or spots in the fields the condition of the wheat was found better. For instance, along the sides of the dead furrows almost all of the wheat was found to be in a perfectly healthy condition, while on the back furrows it was usually all dead. Again, at the corners of fields where lands were plowed around, and the horses in turning had tramped and compacted the plowed ground, the wheat was found to be in fairly good condition. The horse-foot and wheel tracks invariably had a favorable effect. This is a condition and result that is corroborated by all investigators, that if there is plenty of moisture in the ground there is little or no danger of freezing or winter killing, while if the soil conditions become too dry serious results follow. The same was fully shown in the quotation from the Illinois Agricultural College Bulletin, portions of which we quote under the heading of "Raising Trees." These conditions bear out all observation, both with reference to the fact that compacting the soil will increase the water contents of the packed portions, and the further fact, as stated by the Illinois Bulletin, that if there be plenty of moisture about the roots there is practically no injury from freezing.

One point which we have tried to impress upon our readers at several different points is the difficulty and danger that may arise in even a short time when the roots may be just a little short of the necessary

moisture, and the importance of having a compact condition of the lower portion of the furrow slice to lessen the danger. Prof. King has shown. by practical experiments, and all observation confirms his conclusions, that in soil that is packed the moisture moves upward from a depth of from one to four feet much more rapidly than in loose soil. It is therefore important to have this packing when a condition of extreme drought is reached, as it may be the one thing that will save a crop.

It must be borne in mind that Prof. King experimented in packing at the extreme surface, where nearly all the moisture that had moved to this point was lost by evaporation, and that had the packing been done just below the surface the contrast would have been much greater. This fact should also be borne in mind, that Prof. King's experiments were on the grounds of the Wisconsin college, where soil moisture is invariably found all through the soil down to sheet water. Had the experiments been made in our semi-arid region, the contrast would have been greater. If we get our soil moistened here to a depth of four or five feet we have exceeded by some distance the usual conditions, and this depth of soil moisture would be sufficient to carry us any ordinary season in the successful growth of crops. Had Prof. King's experiments been made with a three-inch layer of loose soil mulch above the packed portion, they would have shown a much greater increase of moisture at the point of 2 to 18 inches.

All these facts in connection with the movement of moisture in the soil, under different conditions of the soil, as indicated in the experiments noted and the teachings of the most eminent students of soil physics, give us the valuable lesson that the packing of the subsoil, or what may be properly termed the root-bed, aids us in these important points; increasing the water holding capacity of the soil facilitates the movement of the water from below up to this point when it is needed, is conducive to a much greater development of root growth; and still further, and quite as important, enables us to utilize the entire soil, having no waste ground caused by a loose or porous condition of the soil as shown in cut No. 5.

This is so important that it may be stated again plainly, so that no reader may misunderstand. The process of packing the under portion of furrow or plowed ground creates three conditions to aid in carrying the growing crop over long dry periods, namely:

1. More water in the soil.
2. A stronger capillary movement of water.
3. More prolific growth of roots.

Don't pack the surface; it increases the loss of moisture by evaporation.

Less seed is needed in packed soil than in loose soil for the same crop result.

Pack the lower portion of your plowing the same day you plow, to save the moisture.

Winter wheat will not winter-kill in firmed, moist soil, while in loose soil it frequently thins out or kills out entirely.

A fine, firm root bed, with a loose surface or mulch, is a condition that will withstand the extreme dry periods longest without any injury to the plant.

Study well the question of thoroughly pulverizing and packing the lower portion of the plowing; a full understanding of its importance means many dollars, because it means a larger crop result.

Sub-surface packing increases the moisture in the lower portion of the plowed ground and induces decomposition of the weeds, stubble, or manures that have been turned under, thereby adding humus, the all important soil ingredient for rapid plant growth, as well as enabling the plant to withstand drought.

If you would get your soil to a condition of fineness and firmness, do all your work to that end when the soil is just slightly moist, for it then plows better, packs better, and cultivates better. Do not go to work on plowed ground that is dried to the bottom, whether plowed in good condition or not, and expect in any way to get the lower portion of the furrow in good condition. You may improve it. The closer you keep to the plow the better you can pack the under portion.

THE DISC HARROW, ITS USE AND ABUSE.

To my mind there is scarcely an agricultural implement more important to the western farmer than the disc harrow. Its usefulness however, from its first conception to the present time, has been more or less misunderstood by the farmer. Thousands of acres of wheat have been put in by the use of the disc harrow alone, that has not turned the farmer any profit, and many times a loss of not only his labor but seed. The great value of the disc harrow lies in its adaptability to the protection of moisture, and the preparation of the surface soil for the encouragement of rapid percolation of the rain water. It has been used on thousands of acres in lieu of plowing, when it should have been used to precede the plow. We have quoted, under the heads of Evaporation and Cultivation, instances where the early use of the disc for the sole purpose of preventing evaporation and preparing the surface to receive and utilize further rains, has resulted in giving the farmer increased yields of corn as high as twenty bushels to the acre. Think of twenty bushels of corn per acre for only 50 cents of extra expense! In

the handling of fields for summer culture there is no tool that can take the place of the disc harrow, cost of labor and value of work considered; and while it is not a tool that can be continuously used, we do not see how a man can successfully handle an orchard without it. The disc harrow cannot alone be used to prepare a field for a crop, but in connection with the plow its work is most valuable. The complete pulverizing and thorough separating of the particles one from another in its rotating action, when proper diameter of disc is used, is perfect.

SIZE OF DISC.

When disc harrows first came in use the common size was 14 inches in diameter and this size we still prefer, but the demand seems to be for larger discs, the farmers conceiving the idea that they draw lighter. While this is true the pulverizing effect of the 16 inch is not as good as the 14, the 18 inch even less, and a 20 inch we would not have on a farm. Just a moment's thought on this point and you will readily see the reason. The larger the disc the slower it revolves, consequently the pulverizing effect is decreased as the size of the disc is increased. I have noticed 20 inch discs rolling along when soil was somewhat dry, and simply slice the soil, raising it up a little and letting it fall back in exactly the same position it was before the disc passed over. The process simply made these little crevices and actually increased the evaporation of moisture, instead of decreasing as it should do. A 14 inch disc moving along at the same rate of speed would revolve faster, therefore, pulverize and completely reverse the soil.

Don't buy a disc too large in diameter. The smaller the diameter of the disc the finer and more completely it pulverizes the soil.

A large diameter disc draws easier but does not do as good work. Always double-disc by lapping half; this leaves your field level.

CULTIVATION.

There is probably no question connected with soil culture that has received more attention, and has been more thoroughly discussed than that of cultivation of corn, potatoes, and other growing crops. In the past few years we have heard much about shallow cultivation. In fact it seems to be the prevailing idea. It needs no argument with the average farmer to-day to persuade him that deep cultivation with the old long pointed shovels is not the thing. Shallow cultivation is not, however, well understood. There are many important points not generally observed. In cut

No. 6, we show a hill of potatoes which has been grown by shallow cultivation. It is proper to add that this ground was first plowed eight inches deep, having been previously disced, the plow followed with a subsurface packer, and the whole portion made thoroughly fine and firm. In securing this illustration, the lateral roots of many different hills were washed out. The main roots running from the stock were almost inva-

Cut No. 6.

riably found to have traversed in quite a uniform distance from the surface of moisture; the little branches running out from the main roots taking various directions, some lateral and some down. This illustration quite perfectly shows all these important facts. Notice the two and a-half inch mulch, and the very fine, uniform condition of the balance of the furrow or plowed portion, where may be seen numerous roots. This represents a hill of potatoes taken from a field grown on our farm in Brown County, South Dakota. in 1894, when thirty-two acres of high. level prairie

produced an average of 142 bushels to the acre, and this in a season when almost all crops throughout the entire semi-arid belt were ruined by the extreme drought.

In cut No. 7, we give another illustration of potatoes grown under other conditions. This ground was treated practically the same as that shown in cut No. 6, but deep cultivation was applied, and less frequent.

Cut No. 7.

This field was cultivated three times, cutting fully four inches deep, which resulted in destroying nearly all the main lateral roots, while the other field was cultivated eight times, cutting about two inches. The difference in the result of the two crops was attributed directly to the treatment of the ground after planting.

The main point we wish to show here is that time and manner have even more to do with the result of the crop than the kind of cultivation. If you would secure the greatest possible benefit from the labor given

over to cultivation you should first provide yourself with some fine-toothed cultivator, so that the soil may be all thoroughly fined, leaving the surface of the firm soil beneath as near level as possible. Then, great care should be taken to catch your ground in proper condition. It is true there is but little time after a rain that the ground is in the best pos-possible condition. This is the time when the free water is all percolated below, and the soil to the depth which you wish to run your cultivator, is simply moist—not very wet nor very dry. In this condition the little particles seem to readily separate, one from the other, then your stirred soil is composed of an innumerable number of little, minute lumps, forming a mulch that gives you the highest degree of protection. A mulch made when soil is in this condition will never blow.

If the soil be too dry it breaks into large lumps which not unfrequently lay in such manner as to direct volumes of air through the large spaces between them down to the solid and firm soil beneath, causing much loss by evaporation. It is needless to mention the difficulty arising from cultivating soil that is too wet. When worked it becomes what is known as "puddled," and then when dried it becomes hard as brick and a heavy rain is required to even dissolve the lumps so that they may afterwards be pulverized.

SAVING WATER BY CULTIVATION.

There are two vital points in regard to the successful growing of crops in the western country, and the average farmer appears to find it difficult to comprehend either. This is largely because of his past experience in the more humid sections of the country where it was not necessary to consider or study these questions. The first is the importance of getting all the water possible into the gronnd, and second, using every possible means to conserve or retain it there.

The importance, or value, of a little additional water is shown by the effect of snow drifts that may form on the field from any cause. The increased amount of moisture that seems to find its way into the soil when the snow melts invariably makes itself apparent in the growing crop as soon as a dry period begins to affect the crop in the least. At these points the crop always holds out longer, sometimes carrying the crop over to another good rain, which results in maturing an unusually large yield on these places, while the balance of the field will not yield to exceed one-half or one-fourth the amount. Thus a gain in yield of wheat of probably ten bushels to the acre is the result of perhaps not over one-half inch of additional water that had percolated into the ground. The enormous evaporation from our fields under favorable conditions is not in the least comprehended by the average farmer because he has no means of readily testing and proving.

Under the heading of Evaporation, we have given the results of some experiments by Prof. King of the Wisconsin Agricultural College, showing the rapidity with which moisture will rise through the soil by what is known as capillary attraction, reach the surface and pass off in vapor into the atmosphere in a single day. Not until the farmer begins to grasp the vital importance of keeping even a little additional water in his soil can he be expected to use all due diligence in preventing this evaporation. The observation of the farmers throughout the semi-arid west, during the growing season of 1901, especially Kansas and Nebraska, ought to be amply convincing with reference to the value of stored water in the soil. There were frequent remarks during its prolonged and severe drought of the mid-summer with reference to how the corn continued day after day and week after week contending against this extreme heat without rain, without showing any apparent effect of drought; but this was simply the direct result of the unusual heavy rains in early spring that percolated down into the soil, in many instances 18 inches to 2 feet deeper than usual, and there acting as a reserve, continued to return by capillary attraction and feed the corn plants and other grain until it was exhausted. In this same chapter on Evaporation we make mention of several instances where the early discing of the ground resulted in retaining a sufficient amount of additional water to carry a crop of corn through, increasing its yield in some instances as high as twenty bushels, which was not secured in adjoining fields, not disced, simply because the moisture was allowed to evaporate by leaving the surface hard and compact, as is always the condition after a heavy rain or snow.

To the average farmer who has been accustomed to doing his work in the cultivation and plowing of his fields at times when most convenient, it seems rather difficult to grasp the full importance of doing all his work just at a time when the condition of the soil is best adapted. To grasp the idea that by plowing to-day we may get ten bushels of wheat to the acre, when if we plowed the ground four days later we would get fifteen bushels or vice versa seems rather ridiculous. While this statement and the figures used, may in most cases be a little strong, yet it is a fact that the average yield of a field is frequently increased or decreased quite a per cent. by a few days variation in the time the work is done. This is especially true with reference to cultivation. I have in mind a case near Fairmont, Neb., where the phenominal difference of fifteen to eighteen bushels per acre was made by cultivating a part of the field before a heavy rain of nearly five inches and the balance of it after this rain. The reason of this remarkable difference was simply what we have been dwelling upon, the result of retaining a large per cent. of moisture by the soil mulch produced by the cultivation after the rain, that was lost from the balance of the field by rapid evaporation. This occurred in July, and was the last cultivation preparatory to what is called laying the corn by. The rain was a

very heavy one. The part of the field that was cultivated previous to the rain was left with the thick compacted crust made by the heavy fall of water, which resulted in dissolving the loosened soil and settling it very close, thus leaving the surface in the best possible condition for a rapid movement of moisture to the surface and evaporation. Under the head of Capillary Attraction we have explained this more clearly. The portion not cultivated previous to the rain was gone over as soon after the rain as conditions would permit, thus producing a perfect protection to the moisture below, and bringing about the remarkable result referred to. While these cases cited seem like extreme instances, under similar circumstances you can look for similar results. When the reader begins to understand the direct effect of these conditions it will then be quite clear why a light crop was secured when a good crop might have been harvested.

AS TO TIME OF CULTIVATION.

The proper time for cultivating a field is one that cannot be fixed without much thought, observation, and judgment by the farmer, especially if he would get the best results. Always cultivate immediately, or as soon after a rain as conditions will permit you on the field, and the soil is sufficiently dried so that it will not adhere to the cultivator teeth, or tools used. We do not mean by this that the soil should be absolutely dry on the surface. It is an error to wait for that time, for the moment the surface is apparently dry the crust begins to form. It is desirable to catch the ground just before this time when all the soil is simply moist and then there is a free and ready separation of all particles. In this condition the cultivator runs the easiest, the mulch made the finest and lies up light and loose. If the soil is a little too wet it settles, and not unfrequently forms absolute and perfect connection with the firm soil below, steadily carrying moisture to the surface. If too dry the cultivator produces an imperfect mulch that gives us but little protection.

Another and very important idea is that every moment's delay after the soil reaches the proper condition causes you to lose water very fast. It is at the rate of a quart or over per square foot per day providing it is clear sunny weather, and even more in case of heavy south winds. The more intense the heat the more frequent is it necessary to cultivate. A very good rule is to watch the condition of the firm soil just beneath the loose mulch or cultivated portion, and whenever the surface of this firm soil begins to show dryness it is high time to commence cultivating again. If the field is left too long during the extreme dry period the surface of the solid soil beneath the mulch will begin to form a crust, practically the same as is shown on the surface of the soil when uncultivated after a rain. This is the result of the soil composing our mulch reaching a high degree of heat, causing the moisture from the surface of the solid soil to form into

vapor and pass up through the mulch. The forming of a crust under these conditions, as is also true on the surface, is largely the result of the salts and alkalies that are in a soluble condition, while the soil below is wet. As the moisture from the surface begins to evaporate it leaves these chemicals deposited in the little spaces between the soil particles practically cementing them together. As the process goes on, the moisture line lowering, the surface becoming dry an eighth, quarter, or half inch, possibly an inch in depth and is filled with these chemicals which is quite detrimental in the free circulation of air.

EXPERIENCE WITH AN ORCHARD.

We cannot impress this point more fully upon your mind than by relating our experience with the orchard at the Pomeroy Farm during the season of 1901. We began our harvest just as the extreme hot weather and high winds from the south set in. About seven days before commencing harvest we had cultivated the orchard with the Acme harrow. Our mulch was a good depth and the moisture condition perfect just beneath it. The high winds and extreme heat delayed us materially in our harvest, and sixteen days had elapsed before we were able to reach the orchard again, as help was scarce and our grain shelling badly from the fact we could not get at it. We attempted the cultivation on the 17th day after the last cultivation with the Acme harrow, but the nine days of excessive heat had so heated the mulch as to draw the moisture from the solid soil beneath until a crust of fully half an inch had formed. The crust had become very hard in this time and its resistance was so great the Acme could not break it. At about this time, or within a day or two, we noticed the color of the leaves on our trees began to change to a lighter cast. Not until noticing this did we give special attention to the soil condition, but noting this crust under the mulch we immediately ordered one-half the orchard double disced with instructions to cut a full inch and a half deeper and awaited results. About the fourth day there was a perceptible change in the color of the leaves on the portion disced, and on the seventh day the difference was perceptible to any one. The leaves again took on their bright green glossy appearance, and new leaves coming out then we ordered the balance double disced. We had nearly three weeks of extreme heat after this, and yet during all of that time the trees were pushing out new leaves, and at the close of the dry period were to all appearance in as healthy and thrifty condition as at any time during the entire growing season. The changing of the color of the leaves in this way was not due to a lack of water at the roots, but simply the lack of air.

We had a similar experience, but more clearly illustrated, in the cultivation of corn in Cheyenne county, northwest Kansas, in 1898. This demonstrates very clearly the great importance of being exceedingly cautious,

not to let any crust form under the mulch. We are of the opinion that many corn crops have been seriously injured by that condition, when with no more available moisture the crop would have come out all right had it not been for this crust.

The best possible condition for rapid, healthy growth of plants is when the soil is fine, firm, and as full of moisture as it will naturally hold from the mulch down. This condition can be kept if the mulch be finely pulverized by catching the soil at the proper condition after the rain, holding it a proper thickness and recultivating as soon as the top of the firm soil begins to show the least indication of dryness, providing, however, that a sufficient amount of moisture has been stored below before planting the crop or during its growing period.

KEEPING THE MULCH IN CONDITION.

There are many important reasons why great care should be taken to keep the mulch in perfect condition and prevent the loss as far as possible of any moisture by evaporatiou from the surface of the soil. The following paragraph taken from Prof. King's book on "The Soil" conveys some important information along this line. We quote this because it bears the figures of his own practical observation at various depths in the soil, showing the effect not only of the surface soil getting too dry but of light showers. He says:

"When the surface soil has its water contents reduced so the upper 6 to 12 inches is beginning to get dry the rate of capillary rise of water through it is decreased and it begins to assume the properties of a mulch. But when this condition has been reached if a rain increased the thickness of the water film on the soil grains without causing percolation the capillary flow may be so certain that the surface foot draws upon the deeper soil moisture at a more rapid rate than before, causing a trans-location of the lower soil moisture, the deeper soil becoming measurably drier soon after such a rain than it was before, while the surface foot is found to contain more water than has fallen upon it."

He cites the following experiment, as proof of this important principle. At 5:30 p. m. samples of soil were taken on a piece of fallow ground in one foot sections to a depth of four feet. Water was then applied to this surface at the rate of 1⅓ pounds to the square foot. Samples of soil were also taken adjacent to this wetted area to serve as a control experiment, and nineteen hours later corresponding sets of samples were again taken with the result stated below:

POUNDS OF WATER PER CUBIC FEET OF WET AREA.

	1st foot.	2nd foot.	3d foot.	4th foot.
Before wetting	11.78	15.79	14.73	14.03
After wetting	14.06	17.52	15.58	15.40
Gain	2.28	1.73	.85	1.43

POUNDS OF WATER PER CUBIC FOOT OF AREA NOT WET.

	1st foot.	2nd foot.	3d foot.	4th foot.
First samples	12.38	17.05	14.92	14.48
Second samples	12.75	17.72	15.40	14.17
Gain	.37	.67	.48	.31

Now it will be seen from these results that the water contents of the soil increased on both areas, but at the rate of 6.23 pounds to the square foot on the portion wet, and 1.21 pounds on the portion not wet. The nineteen hours which intervened between the taking of the two sets of samples was a period of very little evaporation, most of it being in the night, and the following morning was cloudy and very damp and the result was that capillarity gave to the area not wet 1.21 pounds more water per square foot than it lost by evaporation, but the wet area had gained 6.23 pounds and yet only 1⅓ pounds had been added to the surface, making the increase by capillarity 6.23–1.33=4.90 lbs., and if we subtract from this the amount which the controlling area gained we shall have 3.69 pounds as the water gained due to the wetting of the surface, or 45½ tons, or nearly half inch of rain per acre. We mention this to show the remarkable effect of these simple conditions on the changing of location or movement of moisture in the soil. It will be seen from Prof. King's statement that if we allow the evaporation of our surface soil to such an extent as to dry to some depth it is then more difficult for the moisture to rise up from below to feed the plant; or in other words it moves much slower, thus showing the importance of watching the conditions very closely. If there should be such a remarkable effect upon the soil one, two, three, and four feet below the surface by simply slightly wetting the surface what may we expect from the effect of a slight rain upon our moisture just beneath the mulch. This shows the very great importance of cultivating as quickly as possible after such rains. If the reader will observe and consider closely the last few remarks he will readily see that by simply shallow cultivation, even though more frequent, and later cultivation, it is still possible to have come far short of accomplishing the best possible results. It is these little quite important points that the average farmer does not in the least comprehend that we have frequently referred to that often causes trouble sometimes quite serious.

In closing this chapter we venture to repeat that we may emphasize some things taught.

Use the long toothed weeder frequently in the early growth of corn and potatoes. It is a great weed killer and moisture saver.

Try to cultivate when soil is in best condition. Put in long days then. Cultivation early in the morning and late at night is better than mid-day work.

Cultivate to save moisture in the early spring and late fall as well as during the growing season. Moisture lost in the fall may be much needed in the coming spring and summer.

Don't keep the old 4-shovel cultivator because you think you cannot afford to buy one with eight or ten shovels. It is poor economy to go on with the old kind. It will lose corn for you every year; and the drier the season the greater will be the loss.

Time and manner of cultivation has much to do with the final yield of the crop. Don't let the weeds grow—they are robbers and should be arrested. Cultivation does not gather or make moisture, but prevents the evaporation or loss of it from the soil.

The more you cultivate with care the more moisture you have in the soil for plant growth. The object of cultivation should not be alone to kill weeds but to save moisture; if due attention is given to saving moisture weeds cannot grow. Weeds should not be the indicator to show when there is to be more cultivation.

Do not cultivate too shallow. The cultivator, like the plow, always appears to run deeper than it really does. Two inches into solid soil after a rain with a fine cultivator at the proper time will make 2½ to 3 inches of fine, loose mulch, and this is all right under ordinary conditions, but in extreme heat during long dry periods, 3 to 3½ inches of loose soil mulch gives better protection.

While the cultivation of wheat and other small grain when sown broadcast or with the close drill is a comparatively new idea, yet no thinking man can deny its importance. The introduction of the weeder has made it possible and successful. If the root bed has been made fine and firm these crops can be greatly benefited by this tool, as the long flexible teeth slip around the well rooted wheat and yet the young and tender weeds are readily destroyed and the surface soil loosened to prevent further evaporation.

SUMMER CULTURE.

COMMONLY CALLED SUMMER FALLOW.

The question of summer fallowing is another part or portion of soil culture that has been brought from the east to the semi-arid west, and applied with the same rules and ideas that prevailed in Michigan, Ohio, and the eastern states. Its purpose was to give the land a rest. It has been applied to many portions of the semi-arid belt, and the advantages generally derived have been so meager that the plan seems to be losing favor. We have given considerable attention to this, and we believe brought out some valuable points or ideas to be practiced in the semi-arid belt. In treating the land as we would suggest we do not think the name, summer fallow, applies. Therefore term it summer culture; beginning the work as early in the spring as the frost is sufficiently out of the ground and the surface dry enough to permit the use of the disc harrow without the soil adhering to the disc, going over the ground twice by lapping the disc one-half. This produces a mulch which prevents evaporation; also opens and loosens the surface, so that the later rains readily and quickly percolate into the soil, going over the ground after each subsequent rain with a harrow, or if the rain is too heavy so as to dissolve and pack the surface, a second discing may be necessary, especially so if the season is advanced far enough for weeds to start freely. Don't at all hazards permit the weeds to grow or the surface to become crusted, bearing in mind our main object is to *store* the water in the soil below. Plow in June or early July about seven inches deep. Do not leave the field at noon until that which has been plowed during the forenoon has been gone over with the sub-surface packer, if such a tool you have, if not, use the harrow. (If you have no packer, borrow one.) Then at night the same, and if you use the packer follow it with the Acme harrow at night, going over the entire day's plowing. The common harrow produces very fair results or conditions, but the Acme once over will put this ground in better condition than two or three times over with the common harrow. In June and July weeds are quite persistent and great care should be taken not to let them get the start of you. In fact there is but little danger of weeds if you take care to lose no water by evaporation. All weeds are easily killed when small, but after the tap root has gone down and become firmly imbedded, the harrow, even the Acme, is not sure to destroy it. Watch the condition of your field, going over it as soon after a heavy rain as the soil will permit, using the Acme if you have one, and set it to cut about two inches deep in the solid soil. This will make you a light, loose mulch from 2½ to 3 inches deep. Continue this persistent care through the season; in case

of extreme heat more frequent cultivation is necessary. If it is desirable to put in spring crops, it is a good idea to thoroughly disc the ground as it goes into the winter. Then use the Acme early in the spring, just as soon as conditions will let you on to the ground, unless the ground has become unusually firm by the heavy snows or rains, then it is advisable to use the disc, lapping half.

While this plan of summer culture seems to outline considerable extra work over the old plan of summer fallow, it will be found the most profitable part of the work. As we have pointed out under this heading, and several others, the great question for successful crop growing is ample available water during the entire growing season. The leading question with the farmer is how shall he increase his crops.

It is altogether too common an idea that the quantity and quality of the crop depends upon the climatic conditions. There is no place in the great plains country where this theory applies with less appropriateness than in the semi-arid belt. The success of the farmer depends to a great measure upon the quantity and quality of the grains and vegetables that he raises. Under the ordinary plan of farming the expense of fitting, planting, and cultivating is just the same whether you get fifty bushels of corn or five bushels or none at all. While if we proceed properly our expense in the work is slightly more, possibly 50 per cent. more, but even though it was double, and we succeed in getting twenty-five to thirty bushels in seasons when our neighbors under ordinary conditions get five or ten, does it pay? Again, if we are able to get sixty bushels of corn when our neighbor gets thirty, does it pay?

THE FARMER'S CAPITAL.

The farmer no more than the merchant can succeed without capital. The merchant deposits his cash in the bank and draws upon it when he needs it to take advantage of bargains or conditions. The farmers' capital is the fertility of his soil, which is not available in any sense without water. Therefore the farmer, like a good collector in business, should catch the rainfall at every opportunity in all seasons of the year and store it in the ground where it is available in time of need, providing he keeps it locked in with the soil mulch. We need not mention here the long line of troubles and disappointments that follow the failure of a crop, or the reverse when we succeed in growing a large crop. It simply resolves itself into this. First, find out what to do, then find out how to do it, then do it with all your might. There is no condition, position, or business to which this rule will apply with more gratifying results than to the summer cultivation, and general care of the soils in the semi-arid belt.

In the question of summer culture the main object is to store the water, but this is not the only advantage gained. There are two other

points, one of which is a some-what recent discovery but apparently quite correct, and this is, that moisture stored in the ground is more valuable for plant growth than the same quantity of water having just fallen from a rain. Professor Shepherd of North Dakota, makes the assertion that one inch of stored water is equivalent to two inches of rainfall. We are inclined to believe that he is correct. By holding the moisture near the surface during the more heated portions of the season we succeed in securing a more complete decomposition of the vegetable matter in our soil, passing it on to the stage that is known as humus, which is a most valuable element in our soil. The more humus we have the greater amount of moisture we can hold in the ground. This, coupled with the amount of moisture that we are able to store, and the improvement of the physical condition of the soil by the discing, plowing, and frequent cultivation in our Summer Culture brings about three conditions. The better and more careful our work is done the more ideal are these conditions. By the very fine, compact condition our soil will hold more water, consequently our plant is less liable to suffer from a lack of water during extreme heat. This compacted condition is also, from the fact of the more minute pores in the soil, favorable to a more rapid movement of moisture by capillary attraction, and last, but not least, conducive to a more prolific growth, and a more general and uniform distribution of the roots. All three of these conditions are exceedingly important in seasons like that of 1901, when weeks go by with continuous extreme heat and no rain, and such seasons or conditions always come without warning.

It is not out of place to here quote again from Professor King's book on the soil. Under the heading of physical effects of fallowing, he says: "That form of tillage known as fallowing, exerts marked physical and chemical effects upon the soil not felt at least with like intensity on lands heavily cropped. One of the most marked effects produced by fallowing is that exerted upon the water contents of the soil. Not only is the fallowed ground more moist during the cultivation period, as indeed should be expected, but the influence is felt the following spring, and even at the end of harvest after the crop has been removed from the ground."

After some careful observations, he found that in the spring succeeding a summer fallow after all of the fall, winter, and spring rains, that the land which had been fallowed contained in its upper four feet 203 tons per acre more water than did that which had been cropped the season before. Nor was this all, for at the end of the growing season and after large crops of oats and barley had been harvested from the land, there was still a difference in the water contents of the upper four feet, amounting to 179 tons per acre. That the differences here recorded were not due to inherent differences in the soil is proven by the water contents of the same lands taken at three different times before the fallowing experiments began. Here are quoted some remarkable facts with reference to results in

increased quantities of moisture, even in the more humid sections of Wisconsin. Had these observations been made in the semi-arid belt, with the same persistent cultivation as applied by King, the difference would have been three or four times the amount noted above. It is a fact, that holding the moisture near the surface of the soil during the heated portion of the season causes a complete decomposition of the partially decomposed vegetable matter which is found in large quantities throughout the surface soils in the semi-arid west, and passing it on to the stage known as humus, thus increasing both the fertility of the soil and its water holding capacities. At the close of Professor King's remarks on this subject, he says:

"In very wet climates, or more especially in those which have heavy rainfall outside the growing season, so that excessive percolation and loss of plant food through drainage is large, summer fallowing in broad fields cannot be recommended. But in dry countries where the loss of plant food through drainage channels is small, and sometimes practically nothing, broad field summer fallowing may prove decidedly advantageous, because with the deficient rainfall there may not be moisture enough to mature a paying crop, and at the same time develop a sufficient store of plant food from the native fertility of the soil to meet the demands of the next season."

In this assertion Prof. King is very modest, but he does bring out some very important points which, with us, are vital in the semi-arid belts, and mean much in future results. The summer fallow idea in mind by Prof. King does not anticipate very much cultivation. While in the summer culture, of which we have outlined, we have been able to store the waters to a depth of nearly five feet in one season's cultivation, where adjoining fields having received ordinary cultivation were practically dry. While in South Dakota in '86 and '87, I practiced the summer fallow idea as referred to by Prof. King, simply plowing in June, turning under a liberal growth of weeds and cultivating the field once afterwards. This field went into the winter with very little, if any, more moisture than the adjoining fields that had been cropped, and the increased yields both seasons were only from ten to twenty per cent., the difficulty being a lack of cultivation or effort to retain the moisture throughout the entire season. More cultivation is needed in the higher and dryer sections than in Wisconsin. It is my opinion, based on practical results and observation of conditions similar to those in Western Kansas, that by the summer culture plan, storing the water the entire season, and raising crops the following year, much larger average crops may be grown than the present average in Iowa or Illinois. In fact, we do not believe we overdraw, when we say that in the more arid portions of the semi-arid belt by the summer culture plan, only cropping every other year, we can raise more wheat in ten years than can be grown in the more humid portions of the belt in ten consecutive crops by the

ordinary plan. In this plan we have the advantage of only seeding half the land and only harvesting half the land. The great value of work along this line lies in grasping fully the idea of storing and conserving the rain-waters. It is the all important element, and if water is stored in the soils of our western prairies, nature has formed the conditions so perfect and so complete to bring this moisture back by capillary attraction to feed the plants during the dry periods that there can be no possible loss by drought. In fact, when the conditions are understood and the necessary labors properly applied, records of phenomenal yields will be numerous as far west as eastern Colorado.

The following from E. F. Stevens, of the Crete Nursery, shows the value of summer culture, even in the more humid portions of the semi-arid belt. He says: "Regarding the possibility of carrying moisture conserved one year over into the next season for use for the next crop. We remember that one year we grew a crop of seedlings on elevated table lands on a part of the divide between the Blue and Salt Creek, just southeast of Crete. Seedlings for their best growth require very frequent cultivation. They are cultivated weekly and oft times twice a week, to secure the largest possible growth and the best grade obtainable in a few months. This superior culture conserved moisture but we did not so understand it then. As a rule a crop of seedlings does not take up all the annual rainfall, so quite a portion of this conserved moisture was carried over until the next season. The following year on this plat of ground previously devoted to seedlings, as above stated, we secured 105 bushels and forty pounds of corn per acre."

This marvelous yield referred to by Mr. Stevens is the direct result of the careful cultivation which resulted in storing a large surplus of moisture, and it is fair and reasonable to conclude that equally as good, if not better, results may be gained in any portion of Nebraska, Kansas, or western Iowa, and Missouri, by following out the plan of summer culture as we have explained under that heading. Another remarkable instance may be mentioned to substantiate these points is that of a piece of corn on the Geneva Nursery ground at Geneva, Neb., in 1894, when the corn crop of the whole country was swept by the excessive hot winds. This piece of corn was grown on ground upon which seedlings had been raised for three consecutive years on the same plan referred to by Mr. Stevens. By the improved physical condition of the soil and the large amount of moisture that was conserved and stored below, both the direct result of the frequent cultivation of the seedlings. This piece of ground carried its crop of corn over and made over 30 bushels to the acre, when all other corn for miles around was entirely ruined. We could add to this many more similar statements, but this is sufficient to show that marvelous results may be attained in crop yield on these very fertile prairies if the proper cultivation is applied. To secure these results the farmers' mind must be clear

on three important points, that the ground must be in proper condition when all his work is done on the soil, that he must have a good seed or root bed, made fine and firm, and abundance of moisture stored below.

Summer culture previous to seeding to alfalfa will assure a positive and even catch and a fair crop the first season.

Summer culture for the storing of the rainwaters in the soil, although comparatively new as above outlined, is a most important adjunct in farming in the west.

Begin your summer culture as early in the spring as the conditions will let you on the ground with your disc harrow. Don't let the weeds grow, thinking they are valuable as a fertilizer to turn under. The moisture they take from the ground is worth far more to you in growing the next crop.

Raising a crop in a dry season is like doing a credit business in hard times. If the business man's bank account is large enough to pull through, he is the one who makes the money; so, too, with the farmer, if he has moisture enough stored below to carry him through a dry season, he is the one who makes the money.

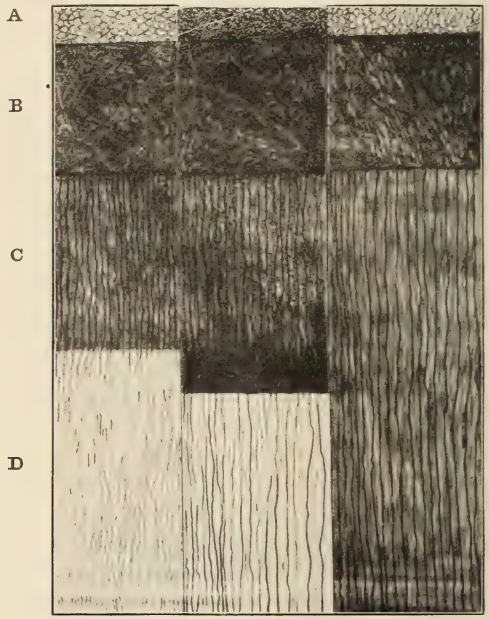
If the farmer wants to raise the largest yield of corn or potatoes he ever had, try a piece of ground summer tilled. This summer culture, or the cultivation of a field one entire season, conserving the water and keeping the weeds out means a surer crop and a bigger crop. Do not give over a piece of land to an entire season of cultivation without cropping just to give the land a rest, but rather to store the water and improve its general physical condition.

PERCOLATION.

OR GETTING WATER DOWN INTO THE SOIL.

There is probably no one question so little understood by the average farmer and yet so important as the movement of moisture in the soil. The problem of getting the water down into the soil is one of equal importance to that of conserving the moisture, which is now quite commonly understood, and accomplished by the use of the soil mulch or surface cultivation. In cut No. 8 we have attempted to illustrate the percolation of water, or the getting of water down into the soil. We have divided this cut into three sections, numbering them 1, 2, and 3 from left to right, then divided these sections into lateral strata A, B, C, and D. In section No. 1, A represents the soil mulch, a stratum of light, loose, and dry soil; B repre-

sents a stratum of thoroughly pulverized and firm soil, meaning the portion that is cut by the plow: C represents about eight inches of the subsoil into which water has percolated; and D represents the portion of subsoil still below that is yet dry. In section 2, we find the mulch has been compacted by a heavy fall of rain. This mulch in its loose condition readily takes in the water, and as soon as the water reaches the moist soil found in strata B and C, it immediately percolates down below, and is



Cut No. 8.

shown by the darker portion of soil in the upper part of stratum D. Here the water has come in contact with dry soil, which resists percolation. Slowly and steadily by gravity the water finds its way down the columns of soil, which, by the way, throughout the entire semi-arid belt are almost invaribly found in a perpendicular position. In sections 3, we have again reproduced our soil mulch by cultivation to stop the evaporation or loss of our water from the surface, and we find the moisture below has percolated on down until the water is all distributed, each little particle taking on its film of water to a given thickness which it seems to steadily hold onto

while the balance of the free water finds its way on down until it is all distributed. The next rain will result the same as is shown in section 2, only we have 6, 8, or 12 inches more moist soil for it to pass through before reaching the dry soil.

A little illustration here may make this more clear. In setting out our cabbage or tomato plants in the spring of the year when the surface is dry and fine we usually water them. Now, in our first application of water to this dry surface we notice the water does not seem to percolate, but for a little time remains dormant on the surface. After a little it finds its way down through the dry particles by force of gravity, leaving each particle it passes covered with a thin film of water. Then we apply a second application of water while the surface is still moist and we notice the water immediately disappears. The reason of non-percolation of the first application is because of the resistance of the dry particles to moisture, or repulsion for water. The quick movement of the second application of water into the ground is the result of the attraction of water for water.

This is a point of much importance, and suggests a little simple experiment that will illustrate this more clearly. Take a piece of glass, or a smooth earthen plate and oil it slightly, then put drops of water, a half dozen or more on the glass, take a narrow piece of ordinary newspaper, about one-half inch wide, let it extend from the thumb and finger about two inches, slowly move it down so the end of the paper will come in contact with a single drop of water. If you notice closely you will see a remarkable resistance of the paper against the water. Very soon the little pores begin to absorb the water, and the end of the paper becomes moist. Now slowly raise the paper and notice how persistently the paper hangs to the water. When it lets go there is a quick upward movement, thus showing the power of attraction of water for water. Now steadily move the fingers down slowly, watching the paper and you will notice when it gets close to the water there is a sudden movement down, even while there is a little space between the moisture on the paper and the water on the glass. The power of attraction is made very perceptible by the quick connection of the two moist particles. Now draw the paper across the glass from one drop to the other, you will notice the water all hangs together. You have a string or train of water two or three inches long, trailing on behind your paper.

This illustrates how easy it is to get moisture into the soil by keeping the surface constantly loose and open, so that as the rain falls it soon works its way through the larger pores until it reaches the moist particles in the firm soil when it immediately percolates on down below. Here again nature has done a great deal for the semi-arid belt. The peculiar formation and size of the usual particle of soil is very favorable for percolation; also for its return upward by capillary attraction to feed the plant during our long dry seasons. The movement of this moisture upwards can

not be better illustrated than by the movement of the oil up the lamp wick. No matter how deep the bowl of the lamp is if the wick reaches the bottom the blaze continues to burn, not only until the oil is all taken from the lamp but until the wick has become quite dry. The same rule or fact applies to the growing plant. So long as there is plenty of moisture below it will move up through the soil to the plant, keeping it in a perfectly healthy condition until the moisture is not only exhausted for several feet down, but the soil near the plant has become apparently quite dry. Then the plant begins to fade and wither.

Study well, by close observation, this question of percolation or getting water into the soil below. It is interesting and of great value.

The deeper you can store the moisture the greater are your chances of securing a large crop.

A piece of ground that is moist for two or three feet down will take in the water of a heavy rain much quicker than ground that is dry. Here again is illustrated what moisture will do for us when we understand her ways and will try to help ourselves.

EVAPORATION.

A thorough understanding of the principles and processes of evaporation is another thing of great importance to the farmer who lives in the semi-arid belt. In fact there is nothing more serious for the farmer than the loss of rain water by vapor, the direct result of the sun's heat and the hot winds. The remark is common in the semi-arid belt that we do not have rain enough, or if we had a little more rain it would be the greatest country on earth, or that all we lack is more rain. To all this we take exceptions. It is true that if we could always have just rain enough, at just the proper time, to enable us to grow mammoth crops without any special effort on our part, it would be very nice; but this is not true in any part of the country. In the more humid sections of the country crops not only suffer at times from extreme drouth, but it is not uncommon that fine crops are lost by too much rain after all the processes of growing and harvesting have been successfully carried out.

The real difficulty in the semi-arid belt is not a lack of rainfall, but the loss of too much by evaporation, and this can be largely controlled by proper cultivation, at least sufficiently to secure a good growth of crops every year. It has been demonstrated by careful laboratory and field work by Profs. King, Whitney, Hillgard, and others, that 7 inches of rainfall is ample to grow a good crop of any kind, providing the water is all utilized

Measurements and records by the government weather bureau have shown that in the more westerly portions of the semi-arid belt the average rainfall is more than twice as much as is needed, while a little farther east it is three and four times the necessary amount.

The usual difficulty, if such we may call it, is the fact that this rain does not always come just at the time the plants most need it. This is the reason crops have failed and the average investigator or observor of the existing conditions in this great belt has drawn the conclusion that there is not rain enough. We have lived in this belt of country twenty-two years, and have experienced all of the pros and cons, and ups and downs, that the country is heir to. Ten years of this time has been entirely spent in the study of the soil, the movement of the moisture in the soil, and that all-important question of storing the rain waters. Our experiences in these ten years have been quite varied, but each and every year some new and important fact has been brought out, all leading to the one conclusion, that the rainfall can be stored in the ground and its evaporation prevented by a proper manipulation of the soil, thus enabling us to secure, not only fair, but remarkably good crops any year.

The present and most modern methods of irrigation have been the result of study along the same lines that we have been working, to wit; that of conserving the moisture in the ground by cultivation after once thoroughly saturating by turning the waters in from the ditches. The most successful farmer today by irrigation, secures better results with one-fourth as much water as was used by the average irrigator some years ago.

The wonderful rapidity with which moisture rises by capillary attraction to the surface and is evaporated is not commonly understood. The most favorable condition for this rapid, upward movement of moisture is the natural condition found after heavy rains, when the surface soil particles are dissolved and settled closely together. Prof. King has conducted some very extensive experiments in ascertaining the amount of moisture that would evaporate from a square foot of ground in twenty-four hours. This work was accomplished by placing a metallic tube one foot square in a tank of water so protected that there could be no evaporation or loss of water, except through this tube. The tube was five feet long, filled with soil from top to bottom, and submerged into the water four feet, so the moisture to reach the surface to evaporate had to pass up one foot through the soil by capillary attraction. The rate of evaporation for ten consecutive days was a quart and a half of water to the square foot. The tube was then lifted one foot higher, making it necessary for the moisture to rise two feet by capillary attraction when the loss was a little over one quart. It was then lifted to three and then four feet, and when rising four feet by capillary attraction the loss was a little over a pint to the square foot. This shows clearly why our crops may suffer so quickly even after we have had considerable rain.

The experience of the writer in his own work in 1894, demonstrated clearly these two facts: First, that moisture will evaporate very quickly when soil is left in its natural condition; second, that a large per cent. of moisture can be stored in the ground. In that year there was no rainfall in the last of May or the month of June, and the average field was practically dry when the first rain came on July 7. At that time the fields were flooded by a rain of 4½ inches which came down quickly. In the fields where we were conducting experiments we had previous to this time got the moisture down nearly 3 feet, and the surface was in the best condition to absorb the fresh rain. In ten days the ordinary field was again practically dry. In such fields, owing to the great resistance of the dry soil, percolation was very slow and the extreme heat which naturally followed quickly evaporated all the water which had fallen. But the field we had been carefully cultivating and had prepared for just such an emergency, was found to have a moist soil over 2^1_2 feet deeper than before, or down to a depth of 6 feet.

During the season of 1901 there were many demonstrations of the remarkable results following extra work done just at the proper time. A farmer near Fairmont cultivated once more after a heavy rain which came about the middle of July, after the farmers in that locality had "laid their corn by." This extra cultivation, which could not have cost over 30 cents an acre, added 15 bushels per acre to his yield of corn. James Armstrong, of Phelps county, double-disced his ground early in the spring, then cultivated his corn once more than his neighbors, at a total cost not exceeding 60 cents an acre, and got 20 bushels of corn per acre for his extra labor. This may seem like an exaggeration, but the comparison was made between this field and an adjoining field on his own farm not thus treated, as well as a comparison with the crops of his neighbors. Dozens of similar illustrations could be given of the immense value of this principle. If the work is done at the right time results are great.

Evaporation of the rainwater on the great plains country has made many a man hopeless and homeless. Prevention of evaporation of the soil waters by proper cultivation means better crops, better homes, better people, happier children, and a better country.

Evidence from all over the semi-arid west proves conclusively that if every farmer had fully understood the theory and principles of conserving the soil water by proper cultivation, there would have been no short crop of corn in 1901 in that section of country. The excessive evaporation of the rain-water all over the great plains country is the direct and sole cause of a greater loss to the farmers of that belt than any other one thing. Educate the farmers of the semi-arid belt to store, conserve, and utilize the rain-water and we have paved the way for thousands more ideal farm homes and a higher state of prosperity than this belt ever experienced or the people anticipated. It is by and through knowledge of certain great

fundamental principles of agriculture, and application of those principles to conditions which exist in this semi-arid belt and no place else in our country, that this region is to come into its rightful own and be made indeed a veritable garden.

CAPILLARY ATTRACTION.

The capillary movement of moisture in the soil is a subject not well understood, in fact, the average experience of the eastern farmer has not demanded any knowledge on this subject, and the early experience of the inhabitants of the semi-arid belt did not call for thought respecting this matter. In short, among the masses of the farmers it is comparatively a new proposition. One of the best illustrations to show the real facts in connection with the movement of moisture in the soil, is that of glass tubes, which we have frequently used in lectures to illustrate this point. A tube about one-tenth of an inch in diameter will lift the water about three-eighths of an inch above the surface. We have about a dozen, the largest a tenth of an inch in diameter, the others smaller, all varying in size down to as small a tube as can be drawn in glass, the smallest probably about one-hundredth part of an inch. In this the moisture will rise about six inches above the surface of the water in which the tube is placed.

The first careful study of the rise of the water by capillary tubes was made by Hauxbee nearly two hundred years ago, but history shows that the phenomenon was known to Leonardo de Vinci, the famous artist, who lived between 1452 and 1519. Notwithstanding the large amount of careful study which these phenomena have received even during recent years, we are yet in the dark as to just how the energy which forces the capillary fluids to move is transformed into current motions, but all who have studied the matter scientifically are agreed that it is in some way brought about through the surface tension of liquids. Capillary movement is somewhat like electricity. We know its existence, we see its effects and have learned something of the various conditions under which its power may be utilized. Capillary movement of moisture, like electricity, has its field of usefulness, and it is now quite apparent that this force within the soil performs a most important office in soil physics.

Aside from the interest which the intelligent farmer will take in this movement as a natural law, it should be thoroughly understood for the especial reason that by capillary attraction the stores of water conserved in the soil below the root bed are gradually lifted up to the roots, as the plants may need the same for their sustenance and growth during a

period of drought. It is by the process of first making the soil near the surface firm and compact and then subsequently, by frequent cultivation as in the Campbell system, holding and storing all the rainwaters in the stratum of soil below, so that this wonderful movement of water upward by capillary attraction may take place and the growing crops nurtured and matured.

It is by the result of this wonderful movement that we are able to go well nigh the western limit of the great prairies of the semi-arid west and there store the rainfall deeply in the soil and then have it by this power return upward through the pores of the soil to feed the plant during the long dry periods, getting large yields in lieu of the oft-repeated failure of the past. When these great points are understood, together with the further fact that the loosening and drying of surface soil of a sufficient depth will practically check any further upward movement, we have a most wonderful condition. By the proper preparation of our soil, that is, the fining and firming of the portion necessary for the root bed, experience has demonstrated that we do increase the power of capillary attraction or the more rapid movement of the moisture from below up. In this soil condition we have one most favorable to the free and rapid development of root growth. Now, if we can comprehend, or be made to understand just how many stalks of corn, wheat, barley, or potatoes can be supplied by this movement to its full demand per square foot or square yard of surface soil, then with our blanket of loose soil spread over the surface to prevent any loss of this moisture so that the roots can take it all in, we have reached a condition that is most wonderful. These facts, when fully comprehended, must and will make of this great semi-arid belt the best and most desirable farming country we have in the United States.

That the fining or compacting, or any manner of reducing the spaces between the particles of soil does actually increase the movement of moisture is very clearly shown by the investigations of the condition of the soil beneath a horse foot track, or where a wagon has passed over a plowed or otherwise pulverized field. Where the soil lies somewhat light and loose to the eye it is apparently dry. Where the particles have been compacted by the weight of the wagon, or the horse, a much larger per cent. of moisture is perceptible. Simple facts like these should not be passed over without a consideration of what they mean. The wonderful uses of which electricity has now reached have been brought about by observing even simpler facts and conditions than this. The development of steam power and the vast amount of labor that is performed by it today, is the direct result of the simple observation of a boy, who placed a cork in the nose of the tea kettle, thus stopping the discharge of steam, when he soon discovered that the cover would frequently lift up by force of the steam and allow the steam to escape. By holding the cover down

he discovered the power. The simple facts referred to with reference to the movement of moisture in the soil have already been proven to mean a great deal.

With the fact that the moisture can be stored in the ground and there controlled and made available to the plant by the aid of capillary attraction, with such results as have been indicated, what are the possibilities of this great semi-arid belt? No one who has ever passed over this country, or remained in it for any length of time, has ever discovered any objections outside of this one fact, that crops and trees have not been successfully grown. All agree that the climate is most magnificent, the soil exceedingly fertile and very easy of tillage. The condition of the majority of the soil in the eastern states, that is, its composition and formation is such as to not be susceptible to the remarkable effects of capillary movements of moisture that are shown in the great semi-arid belt. It is undoubtedly due to this fact that so little attention has been given to this question until recent years. Capillary attraction is known to us and is illustrated by sponges. A sponge is moistened, then compressed, until all the possible water is pressed out, then drop the corner of the sponge into the water, and water is seen to immediately climb up through the entire sponge. The finer the sponge, the more quickly is it filled. This is an illustration that we used some years ago, which is exceeding clear and quite convincing. The lamp wick is another illustration, as the oil is consumed from the end of the wick, more is at hand, and it gets there by no other power than by capillary attraction.

Study these three points carefully. Percolation, evaporation, and capillary attraction; they will be found more interesting the more the reader and investigator understands them, and when fully understood, the question of soil culture will be much better appreciated. You will then comprehend why the plowing should be reasonably deep and the under portion made fine and firm, while the top should be fine, but loose and dry.

CORN.

The question of raising corn is one upon which much may be said. Back in the eastern states among the hills of New York and New England, a large amount of time is given over to the preparation of the soil. Experience has taught them that without fertilization crops are light. Barn yard manure is used freely, and two, three, or four dollars worth of fertilizing per acre is not uncommonly necessary in order to secure good crops. In Illinois the soil is more fertile and rain usually ample, so that no fertilizers

are required and when the rains are ample and timely two or three ordinary cultivations produce a good crop of corn. But even there they are beginning to learn the value of conserving the water by more frequent cultivation, because of dry periods that are liable to come at any time. With us in the semi-arid belt more attention must be given to the preparation of the ground. We cannot depend upon heavy rains to aid us in dissolving and settling our soil, consequently we must give close attention to every part of the work. The first thing in order is the early discing which should be a double discing in order to thoroughly pulverize the surface, bearing in mind that every act must be to store and provide the greatest possible amount of water in the soil. Early discing covers the two important points previously referred to, that of preventing the evaporation and opening up the surface to receive the later rains. This done, we simply wait for the proper time of further fitting and planting, always being in readiness, however, to loosen the surface at any time, should we get a rain of any magnitude. There is some diversity of opinion as to whether the check-rower or lister is preferable, more particularly in the lower altitudes. We favor the lister in the higher altitudes, or in the northern sections, where the nights are cooler, which results in heavier stooling or suckering. These additional shoots are very detrimental to the corn crop, especially so, should we have a dry season, but for the more humid sections we are not yet fully in favor of the lister.

THE LISTER.

The lister has one advantage that is especially desirable. By filling the furrows about the time the shoots begin to show and thereby covering them up we may destroy them completely, which is easily and quite readily done. Another advantage in listing in the more arid sections is that of getting the roots deeper into the ground. The higher the altitude and the drier the atmosphere, the deeper is it necessary to cultivate in order to produce a deeper mulch to prevent evaporation. In using the lister on ground where the moisture has been carefully preserved by discing and harrowing in the early spring it is quite important to follow the lister with some tool to thoroughly pulverize the moist soil that is thrown up (as such soil immediately assumes a dry and very hard condition which is afterwards hard to manage). The best tool for this purpose is the weeder, the long, flexible teeth lap down on the side of the furrow or ridge as thrown up between the rows and quite completely pulverize the large clods that are thrown up by the lister, leaving a perfect circle with a nice fine mulch over the entire surface. This puts your ground in magnificent shape, especially in the sand loam soils of the semi-arid belt, so that you can continue the use of the weeder by going lengthways of the ridges and completely destroy the weeds before they assume any size, keeping your mulch in perfect condition to prevent evaporation, going over the ground after

each rain as in the cultivation of other crops, watching the condition very closely in order that you may catch the ground just when slightly moist before the crust has begun to form. This does away with the weed cutting idea. On the Model Farm we continued with the weeder, using no other tool, until the suckers were well out. Then with the old style four shovel cultivator the soil can be thrown in and then harrowed cross-wise. Here again in this cross harrowing the weeder puts in good work, as it thoroughly pulverizes the surface if you catch the ground in the proper condition and does not injure the corn. After this your ground is practically level, and can be cultivated in the same manner you would cultivate check row corn, or surface planted. At the Pomeroy Model Farm the weeder was used exclusively until the corn was fully fifteen inches high.

CHECK ROW PLANTING.

In planting with the check row planter it is important to plow the ground as early as possible. Here again, the early discing comes in with its all important results to prevent the evaporation, holding your ground in perfect condition for rapid percolation of the later rains. This is advisable because you can get onto your ground with the disc when at a proper depth to plow it would be too wet. Then again, you can cover the field quicker if you have a broad gauged disc than with the plow. It also enables you to get your soil in much better physical condition, than would be possible if the ground was allowed to dry out. The plowing should be followed up soon after, but remember this point, if you have been particularly persistent in preventing this evaporation by the discing, your ground is in perfect condition to plow, even though you have considerable dry weather later on in the spring. The soil will roll up in a moist condition, and is susceptible to the best results with the packer or any other tool. Follow the plow closely with the packer, at least every noon and night, if you have one. If not, then use the harrow in the same persistent manner, but do not plow as deep by at least two or three inches if you have no packer. Five inches is amply deep to be properly worked down with the harrow. After your ground is turned over and the necessary work done to pulverize the surface, watch closely the condition. Whenever any rain of any magnitude comes, even though it only wets through the mulch or loose soil on top, it is necessary to immediately stir it to dry it out.

The importance of quick work after the surface has been moistened, even by a slight rain, is shown in the result of the experiment by Prof. King with reference to wetting the surface as quoted under the heading of cultivation. In the use of the check row planter the difference in the time of germination, the rapidity of the growth of the young plant in ground prepared as outlined under the heading of plowing and subpacking, as compared with corn put into ground in the ordinary manner of fitting is

something wonderfully attractive. The growth of roots as shown under the heading of root development is also interesting. Do not put in too much seed. There are unquestionably many instances where very light crops of corn have been secured from too much seed, when had there been one half as many stalks growing there would have probably been two or three times as much corn. I have frequently heard the remark, if you don't put in the seed you can't get the crop, indicating the crop was guaged by the quantity of seed, but this is another mistake and is begining to be more generally understood. The strongest evidence along this line is found in some experimental work which we conducted in 1897, where eight ears of corn were raised from one single kernel, four ears growing on the original stock, and two each on two suckers or shoots. Seven of these were well developed ears, the eighth having corn about half the length of the cob, both the upper and lower ends of this cob being bare of corn.

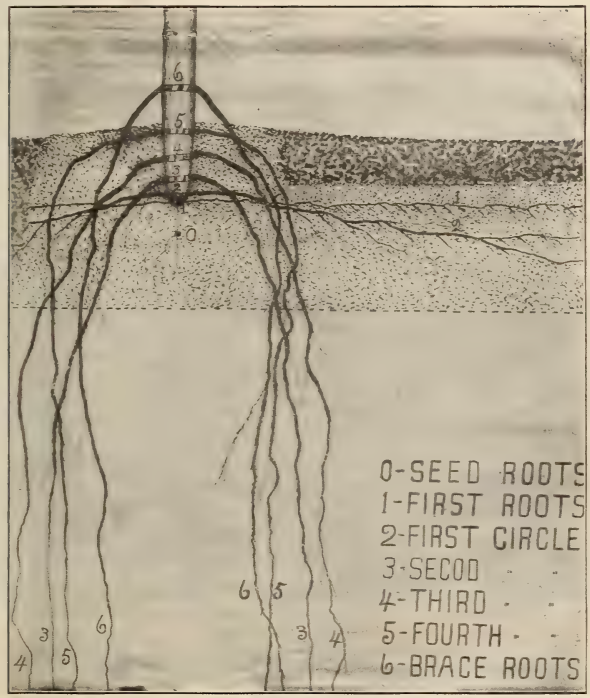
AMOUNT OF SEED NECESSARY.

One fact may not be generally known or understood, and that is that every healthy corn stalk starts from five to ten ears. Now the development of these ears depends entirely upon the physical condition of the soil and an ample supply of available soil moisture and plant food at all times. It is true there are instances, or conditions that might exist by which more corn might possibly be got from two, three, or four stalks in a hill than one. These would be rare cases and where by extreme heat the demands upon the supply of moisture and plant food might suddenly destroy the vitality, or life of all the ears that were started on the corn, except the top one. Then a sudden and liberal rain immediately replenishing the soil about the roots with the necessary moisture which would immediately increase the available supply of plant food and push to completion the single ears left on each stalk, when we would have two, three or four ears to the hill as against one ear if we had but one stalk. Then again should the dry period continue longer without any rain we might lose all the ears, because the demand for moisture to supply the growth and development of two, three, or four stalks would be just that much greater than for one stalk, consequently the one stalk could endure the drouth longer without suffering, and probably reach the next rain when ample moisture would mature one or two good ears as against none at all with a larger number of stalks.

DEVELOPMENT OF THE ROOTS.

It will be seen from these facts that it is possible to secure as large a yield from one kernel in a hill as from three kernels in a hill, and in the semi-arid belts much more probable. In cut No. 9, we show a single stalk of corn and the general direction and development of roots. This illus-

tration was made from several careful investigations of the location and development of corn roots. In the right hand lower corner you will note the figures 0 to 6, each indicating the circle of roots, 0 indicating the first development, or from the germination of the kernel of corn, while No. 1 indicates the second growth of roots, which almost invariably is found to run very close to the surface of moisture. The depth of the early cultivation of the corn, providing we have no immediate subsequent rains to



Cut No. 9.

moisten the cultivated portion, largely regulates the location of these roots, therefore it is well to go slightly deeper the first time. No. 2 indicates the third line of roots, which is almost invariably found, although starting from the stalk a little higher, to make its way to a lower point beneath the line from which roots No. 1 seem to feed. These roots although only shown in the illustration as being single roots running to the right and left as we look at the stalk of corn, yet there is an entire circle around the

stalk running in every direction, providing the condition of the ground is such as to encourage them. Here one can readily see the importance of cultivating as deep the first time as in any previous cultivation, for these roots find their way out through the soil in the early stages of the growth of the plant. Roots No. 3, which is the second circle of roots, are what is properly known as brace roots. These roots like the subsequent roots 4, 5, and 6, find their course very largely straight down into the soil. They, however, convey but a small per cent. of moisture and plant food to the corn. This being almost entirely the work of the roots shown by 1 and 2.

Cut No. 10.

Here in this illustration can readily be seen the serious results from deeper subsequent cultivation, which might result in cutting off many roots. We can also see the importance of all work as outlined under the various headings referring to the preparation and care of the soil being carefully carried out.

Here in this illustration is represented corn put in with the check row planter, the ground plowed fully 7 inches deep, thoroughly pulverized and made firm. Now, supposing we have carried out the necessary work to have stored and conserved moisture to considerable depth, 5 or 6 feet, with our plowed ground thoroughly pulverized and made firm, we have the best possible condition, as stated under the head of Sub-Surface Pack-

ing, for the three all important conditions which we so frequently mention. That of holding the greatest possible amount of moisture in the soil, a condition to promote the most rapid movement of moisture by capillary attraction from the sub-soil up into this finely pulverized portion. Also a condition most favorable to the development of roots and root hairs or feeders. Careful investigation of fields thus prepared after the stalks of corn have reached a height of 3 or 4 feet will show almost a perfect network of these little roots and feeders throughout the entire field. Scarcely a spot half an inch square can be found that is not permeated by many of these little hair roots seeking the moisture and plant food therefrom.

With our moisture in ample quantities below, as stated, and this perfect condition of soil and development of roots, the growth and development of a magnificent crop of corn now depends entirely upon the time, manner and kind of cultivation. It is not absolutely necessary that the farmer should have a specially fine toothed cultivator. The Eagle Claw Cultivator, that carries four shovels on each side of the row, is probably the best in general use. Again we must repeat the importance of watching closely the condition of the soil, that as much of the work as possible may be done at the time, immediately after a rain when the soil is simply moist and the soil grains seem to most readily separate one from the other, as in this condition the most perfect and uniformly fine mulch may be produced.

BROAD-GAUGED CULTIVATORS.

From the fact that it is so extremely important to catch this ground at just the proper condition, a condition that does not long exist after a rain, it is apparent that cultivators on the broad-gauged plan must be produced by our manufacturers. A two or three row machine is very important, that we may cultivate two or three times as much ground in the same length of time, and when the farmers come to understand the importance of rapid work and the demand is made, such tools will be produced, for Yankee ingenuity is prevalent in all of our big manufacturing establishments. Returning to Cut No. 9, and the existing conditions as outlined, if the corn is not too thick in the ground, we never have had a season that a sufficient amount of moisture could not be held about these roots to produce, not only a fair crop, but a remarkably good crop. If the loose mulch on top, to a depth of 2½ or 3 inches, is first produced when the conditions are just right after a rain, and stirred just often enough during the long dry periods, we can practically prevent any loss whatever by evaporation from the sarface. This accomplished, the perfect physical condition of our soil and complete development of roots will take the moisture from below sufficiently fast to prevent practically any damage from extreme drouth, and produce a most magnificent crop of corn.

In Cut No. 10 we show a field of corn grown at Lisbon, N. D., on the Soldiers' Home grounds, by Colonel MacIlvane in 1897. This was one of

the several farms which we had general supervision of on the Northern Pacific in '96-'97. Here, by carrying out practically the same conditions that I have explained by referring to Cut No. 9, 82 bushels of corn to the acre were raised, while the average corn field would not make over 6 to 10 bushels. Remember this is in North Dakota. Again, in Cut No. 11, we show the remarkable contrast between the corn grown on the Pomeroy Model Farm and that grown on adjoining fields under the ordinary methods of cultivation.

TIME FOR INVESTIGATION.

These illustrations, coupled with the facts referred to under the heading of Evaporation, where 15 to even 20 bushels was added to the yield of a field of corn, where only a small part of the work here referred to was carried out, is certainly sufficient evidence to prompt many to make even a small test to find out the correctness of these assertions. If they are true, then it is folly for men to raise 5, 10, or 20 bushels, when by a more careful and thorough plan of cultivation, 40, 50, or 75 bushels might be raised. The Good Book says: "He that tilleth his soil shall be satisfied with bread, but he that followeth vain ideas shall find poverty enough." I think this passage is quite as applicable to the present existing condition in this country as it was then in Egypt.

Plenty of water in the soil makes plenty of corn.

No after cultivation can make amends for a poor job of fitting the soil for crop.

The deeper you can get the water stored down in the ground before planting time the surer are you to get a big crop.

Cultivate your corn at least once after the last rain. If you don't need the water for this crop you may the next.

Don't get the shallow idea too strongly fixed. Two and a half to three inches of fine loose soil is about the best condition.

Watch the first approach of spring and as soon as you can get into the field with your disc, go over your ground intended for corn. Nothing can pay better.

There is no work done, cost considered, that seems to go farther toward increasing the yield of corn than that of early double discing. This is also quite true with reference to all other crops.

Never allow a crust to form under the mulch no more than you would on the surface. It will get there if you don't watch closely during times of extreme heat in long dry periods. Don't let weeds grow. Every weed means less corn.

Don't use the old long pointed four-shovel cultivator. To go deep enough with this tool, to make good protection for moisture you are sure to destroy many roots. The cultivator that leaves the stirred soil the finest and loosest and yet level is best.

Corn from the Modle Farm cultivated by the Campbell method.

Corn from adjoining field by the ordinary method the same year.

Cut No. 11.

WHEAT.

In discussing the question of growing wheat it seems almost necessary to divide it into two headings, winter and spring.

SPRING WHEAT

in the northern sections and on up into Canada, has become a very important crop. In preparing ground for this crop little attention has been given in the past to the all important question of storing and conserving the rainwater. It has been simply a question of plowing at any time when the farmer was ready to plow, the seeding and harrowing likewise, without reference to the condition of the soil, or the storage of water. In the more arid portions of the wheat belt in the northwest there is no question but what summer culture, commonly termed summer fallow, would be found exceedingly profitable. While we have thoroughly discussed this question under another heading referring especially to that of SUMMER CULTURE, yet its work is of such great importance, and the additional expense so little compared to results that we cannot resist a repetition. If the work is properly done the returns are large. Begin first in the early spring, just as soon as the frost is out of the ground, and the soil sufficiently dry to permit of discing without the soil adhering to the disc, lapping half so as to thoroughly pulverize the surface, thus putting your ground in condition to prevent evaporation, as well as to admit of the rapid percolation of the early rains, you will be surprised at results. Then keep the surface harrowed or loosened by the use of some tool to the depth of at least two inches, plowing in June or July, the time when other work is least pressing, to a depth of 6 or 7 inches, following the plow closely with the subsurface packer and let the packer be followed closely with the harrow, keeping in mind that all-important point of working the soil when it is in the best condition to most thoroughly pulverize, continuing this surface cultivation after the plowing through the entire season. In this work again the Acme harrow is most desirable because each time over it brings the soil from below up and to a large extent turns the soil from the extreme surface to the bottom of the portion stirred by the Acme. In this kind of work in the northwest, as well as in any portion of the semi-arid belt, it is very important to do this surface cultivating, whether it be with the common harrow or the Acme harrow, spring tooth or disc, at a time when the soil is in the best possible condition; that is, simply moist, not dry or wet. Then you have a fine even soil mulch composed of minute lumps, a condition you cannot get if the soil is dry or wet. It is when soil is in this condition that the particles seem most readily to separate, not

simply into dust but these minute lumps made from slightly moist soil when dry will never blow.

Having had 15 years experience in the northwest I am well aware of this blowing difficulty on the lighter soils, which can be entirely prevented by care with reference to the condition of the soil as above stated. It is very desirable in following this plan to keep the weeds entirely clean from the field. Don't for a moment harbor the idea that weeds are valuable to turn under, for there is so little value to them that it is not worthy of consideration, but the water drawn out of the soil by these weeds while growing is far more valuable to the coming crop. Watch it carefully. In the springtime try to catch this gronnd as early as possible with the harrow, Acme preferred, and put in your seed, not to exceed one-half bushel to the acre. This quantity is ample. When the wheat begins to stool or send out the additional shoots go over your ground with the weeder to again loosen the surface to prevent evaporation, as well as to destroy the few weeds that may then make their appearance. The long flexible teeth of the weeder will not destroy the grain when at this stage of growth, but will kill the young tender weeds. Then await results. If you have followed the plan fully you are simply sure of a big crop. In raising spring wheat continuously without the summer culture plan the same question with reference to storing and conserving the water should be constantly kept in mind.

If you will give close attention to this point you will simply be astonished at the results obtained. When a crop has been taken off, get onto this ground as quickly as possible with the disc harrow. Double discing is exceedingly valuable. The small size disc 14 or 15 inch, set at a good angle will quite thoroughly pulverize the ground, but with the larger disc it is impossible to get a good condition without double discing. Remember that the object is to thoroughly pulverize the surface two or three inches, to not only prevent the loss of any moisture we may have below, but to have the ground in the best possible condition on the surface for the rapid percolation, or getting of the rain waters down into the soil. Lose no time after any rain in again loosening the surface, (especially upon any ground that you may have already plowed). After the discing, plow and pack and harrow, as stated with reference to summer culture. Should you get any heavy rains late in the fall lose no time in loosening the surface to save the water, for you may need it the following year. When spring time comes get over your ground as quickly as possible with the harrow, aiming if possible to do this before the surface gets dry, put in your seed, not too thick, and await its developments when it reaches the stooling point, which it will do early in the season if your ground is in the condition that such work as outlined above will make it, and you have been careful in conserving the moisture. At this point of growth, that is when the wheat is begining to stool or sucker, go over your ground with a

long toothed weeder. This will loosen the surface and destroy the weeds. The checking of evaporation by this cultivation will urge on your wheat when it will soon cover the ground then the danger of evaporation is much less.

Don't think for a moment that you can get this rapid growth and early heavy stooling of the wheat unless your ground is thoroughly fined and firmed and you have held the moisture below, forming a seed bed in which there will be a rapid development of strong roots which is the direct result of prolific stooling. The use of the weeder or harrow, on wheat after it has begun to stool, or is three or four inches high, when your ground is loose and porous where the roots should grow is not always a safe proposition. The root development is so light that much of the wheat may be easily pulled up and destroyed. Keep in mind three important points, a finely pulverized and firm root bed, abundance of water conserved, and the loose mulch to prevent evaporation, then don't worry about results.

WINTER WHEAT

is a little different proposition from the spring wheat. Here again we believe when the farmer in the winter wheat belt has learned the value of summer culture and how it will not only greatly increase the average yield, but make a failure so far as drouth is concerned an impossibility, a larger acreage will be thus treated. Especially in the more arid portions. In sections where wheat is grown exclusively and continuously care in the preparation of the seed bed, and the storing and conserving of the rain waters is the foundation of success. The experience on the Pomeroy Model Farm, and our results there, certainly carry very strong evidence as to the value of this class of work, where by this very thorough and careful fitting of the soil, having plowed about seven inches deep, followed our plow closely with the sub-surface packer, and the packer with the Acme harrow, going over our fields immediately after the heavy rains or as soon as the soil was sufficiently dry to permit it, we had formed a fine, firm and very moist seed bed. Under these conditions twelve quarts of seed was found to be ample. Its germination was so quick and the rapid development of roots brought about by the very favorable physical condition of the soil caused the liberal stooling, and in thirty days after seeding our ground was nearly or quite covered with the wheat. The immediate discing after the winter wheat crop is removed is of very great importance; as we have repeatedly said, it is of two-fold value, as it prevents the loss by evaporation of any moisture in the soil, and puts the surface in the best possible condition for the rapid percolation of later rainwaters. The plowing may be done a little later, and to get the best results a good depth of plowing is necessary, and then the plow should be followed with the subsurface packer. Mark you, we are after a condition that will not only

enable us to get the best possible results, but prevent the serious damage by drought and assure good crops annually, which means prosperity in its highest degree. A fine, firm seed bed, or root bed, has many advantages over the coarse, loose condition. In the first place one-third of the seed only is necessary. In the next place the growth and development of the plant is much more rapid and will soon cover the surface. In the third place the development of roots is much greater, we are able to draw moisture and plant food from a much larger percentage of the soil, and last, but not least, we have a condition of soil that will hold a much greater per cent. of moisture as well as one having a greater power of capillary attraction, enabling us to keep up the supply of moisture which we draw from below where, by careful work, much of the rainwaters are stored, that under ordinary conditions would have been lost by evaporation or run off.

The plan of raising wheat by plowing every third or fourth year and simply using a disc for two or three consecutive years, or even reducing the cost still farther of putting in the crop by using a disc drill, is altogether wrong. While it is not at all surprising that many farmers resort to this in lieu of simply plowing three or four inches deep, leaving the plowing without even harrowing, laying up light and loose, full of cavities, a condition that could scarcely produce anything but weeds in an ordinarily dry season. Yet it seems like folly for a man to so prepare his ground that nothing but a very favorable season could give him even a fair crop, when with a little additional work, following out the general principles involved, as above explained, he is able to so materially increase the yield, as well as to guard against a failure. No farmer should be content to call 20 bushels of wheat a good crop. Our prairies of the semi-arid belt are capable of producing 40 and 50 bushels, with the conditions nature has provided. It simply remains for man to till the soil properly.

The necessary quantity of seed per acre depends upon the manner you have fitted your ground. In a fine, firm seed bed, with due care to conserving moisture, 20 lbs. of wheat is ample seed.

If you have simply done as little work as possible, then you should add about 60 lbs. more as a sort of a jack-pot, for in such kind of fitting it is a gambling proposition, pure and simple.

If you have your seed bed firm and fine and do not believe in harrowing your wheat, just try a little and note results. If you have a weeder, or can borrow one, then be sure to try a good piece. In using the harrow or weeder, always, if possible, catch the ground as soon after a rain as you can get onto it and not have the soil stick to the teeth. There is big money in such investments.

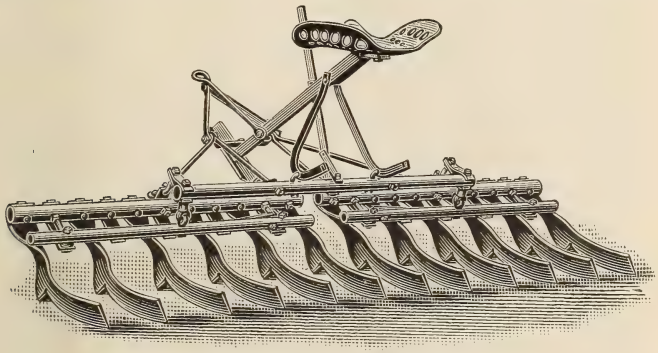
RAISING TREES.

There is no question that is worthy of more consideration so far as the comfort and happiness of a family is concerned which resides on the farm than that of growing trees. There is nothing more delightful after a noon day meal in mid-summer than to quietly recline in a hammock in the shade of a large elm, but this to the average resident of the semi-arid belt for several years has seemed an utter impossibility. There is nothing more easy, or more simple. The experience at the Pomeroy Model Farm during the past two years quite clearly demonstrates this fact. The piece of land selected for the buildings around which a large number of shade and ornamental trees were set, and for the orchard is on a high divide overlooking the town with quite a considerable south slope. The south slope is much more unfavorable than the north, as it gets the rays of the sun more directly and catches the force of the south winds during the extreme heated portion of the season; but this south slope was purposely selected that visitors might see that what could be done under such conditions might be done at any point. For the most successful growing of trees or orchard a northeast slope should be selected as most favorable. The ground for our trees was first double-diced early in March, 1900, plowed in April about 8 inches deep, the plow followed by the sub-surface packer, and the packer with the Acme harrow. The ground was then laid out by using the check chain of a corn planter. A small stake 6 inches long was set for each tree or shrub, and 964 of these stakes were thus set. When the trees were received from the nursery a deep trench was dug and all trees heeled in with tops pointing north. Care was taken to keep the roots from the air, and what is most important, to keep them moist. When taken from the boxes they were quickly covered with dirt and water turned on. A kerosene barrel was sawed in two parts, each half barrel was filled about two-thirds full of water, and sufficient dirt was added to form a thick solution of mud. Then the trees were taken from the trench, when the workmen were ready to engage in the actual work of setting the trees, and they were put into this solution one by one, and enough mud adhered to the roots to keep them protected from the air and sun while being handled during the process of setting.

Two boards 4 feet long by 6 inches wide were provided with a notch in the center and a notch at each end, both boards being cut exactly alike. The man who dug the holes used one of the boards, and placing the center notch on the stake pulled the stake and set it in one of the end notches and added another stake in the other end notch. He then removed the board and dug the hole. In digging the hole the tree was examined to note the

size and shape of root and hole dug sufficiently large to allow spreading all the roots out their full length and no more. The man who directed the tree setting carried the second notched board and after the hole was completed he placed the board on the two stakes, and dropping his tree into the hole brought the body to the middle notch, thus holding it exactly where the original stake had been set.

In setting the tree a helper using a hoe pulverized the dirt that was still fresh and moist, hauling it to the roots as fast as a man could place it with his hands and by the aid of a trowel. Great care was taken to work the soil into and about the roots. When sufficient dirt was in to cover the roots a quart of water was turned in. By vibrating the tree slightly the water soon percolated through the moist soil, dissolving the particles and settling them closely around the roots. The holes were then filled within



The Acme Pulverizing Harrow.

two inches of the top, and then tramped firmly. Then about three inches of loose dirt was scattered over this packed soil and the tree left. This plan was so successful that in the spring of 1901 we were obliged to reset only 17 trees, less than 2 per cent., the trees all having made a very fair growth the first year. The expense of caring for these trees in 1900 outside of the trimming, but including all other work and cultivation, amounted to $22.00, or about $2.25 an acre.

The plan of operation was immediately after setting the trees to double disc the entire surface, because the hauling of the wagons and tramping of the men over the moist soil while setting the trees resulted in packing the ground considerably. A two-horse disc was used for this work, which enabled us to get very close to the tree. As soon as a rain of any magnitude had fallen, the ground was gone over with the Acme pulverizing harrow, crossing the work done with the disc. This harrow is a tool pretty generally known, and a most valuable implement for this class

of work. No weeds were allowed to grow. About two and a half inches of the surface was kept constantly loose and fine by the use of the Acme until July, when a second double discing was applied. The object of this occasional discing was to cut deeper to prevent even the slightest degree of crusting beneath the mulch. Then the Acme was used, going at right angles each time with the previous cultivation until September 1st. Up to this time we had been inclined to follow the ideas of most orchard and tree men and horticulturists, which was to discontinue cultivation after August, the object being to check the growth of the tree and allow the new wood to mature before freezing time. This idea presumedly is correct in the more humid portions of our country. But in the semi-arid section we are inclined to discredit this theory in its full extent. We believe the cultivation should be continued, but less frequent. We must not lose too much of the moisture from around the main roots and their branches, if we would carry our trees safely through the winter. This question is a nice one and must be treated with care. It is proper to reduce the sap in the body and limbs slightly, but there is danger in going into the winter with soil too dry about the roots. Much attention has been given to this point by most of our agricultural colleges the past four or five years.

From Bulletin No. 52, issued by the University of Illinois in 1898, we take the following. We quote it especially because it corresponds to our own experience and is the result of several years of observation:

"Throughout large sections of Illinois may be found the rotting remnants of once extensive orchards, representing large original expenditures of both labor and money. The frequency with which such localities are met would almost seem to justify the statement usually heard in the neighborhood where such worn out orchards are found that the soil is not fitted for the growing of fruit. On the other hand the enormous apple and other fruit production in other parts of the state, and frequently in localities not far distant from those mentioned, makes it evident that the reason so often assigned cannot be the correct one.

"On examination and inquiry it will be found to be almost invaribly the case that the true cause for the failure or the dying out of an orchard is the lack of proficient, or the entire absence of proper cultivation and care. While the Illinois agriculturist has been devoting his time and attention to the care of his field and garden crop, it is too often the case that the orchard has been left to care for itself, with the above mentioned result. The commonest cause of failure in orchards in Illinois may be traced direct to the ill effects of summer droughts, though perhaps it is more commonly referred to freezing in winter. The connection really existing between these two destructive agencies has not been often recognized. The fact that certain varieties of apples usually accounted hardy even to our most northern limits, and in exposed situations sometimes fail after a winter not noted for severity, has at different times attracted atten-

tion, but the significance of such failures does not seem to have been duly appreciated. On consulting the records it is found that orchard injuries and exceptionally severe winters do not coincide. The autumnal condition of the trees clearly has to do with the results, and this again depends upon the developments of the growing trees. One of the worst things that can

Cut No. 12.

happen to trees is the failure of a sufficient supply of soil moisture. A continuous supply of water is essential to all the vital processes of vegetation. Apple trees severely suffer when not so supplied."

The bulletin continues at considerable length along this line, and then presents two very striking cuts, on pages 126 and 127. One showing

Cut No. 13.

the orchard upon the college farm, with trees hanging full of fruit, the other of an adjoining farm with neglected trees uncultivated. bare of fruit and almost minus of foliage, and the bulletin winds up by referring to the two cuts in the following manner, to-wit:

"The photographs were taken in September, 1897. The tree in the foreground of the college orchard, with its wealth of foliage and bending under the weight of its load of fruit, tells its own story, a d stands forth in marked contrast to the preceding picture, which is bare of fruit and almost minus of foliage. From the contrast there can be but one conclusion drawn, that while other things have greater or less effect upon an orchard's health and condition, the prime requisite to successful orcharding in Illinois is thorough and systematic cultivation."

While the principles involved in the Illinois bulletin are important and valuable in that state, they are vital with us in the semi-arid section. The prevailing idea, and the idea usually drawn from most of our articles, is that the work is too expensive to make orchard growing profitable in the more arid portions of this country. This is quite an error, fully demonstrated by the figures given on our own work on the orchard of the Pomeroy Model Farm in 1900.

In cut No. 12 may be seen a peach tree grown on the Pomeroy Model Farm orchard, from a photograph taken in the fall after the first year's growth. These trees were all cut back to about three feet when they were set, and all limbs cut back so as to leave about two buds on each. Cut No. 13 illustrates one of the same trees August 23, 1901, on its second year's growth. The contrast is so remarkable that it may be taken as sufficient proof that trees may be grown in the more arid portions of Kansas without irrigation, and what is true there is equally true in other portions of the semi-arid belt. The body of the tree shown in cut No. 12, at the close of the first year's growth, measured a little over one inch in diameter, while the body of this tree as shown in cut No. 13 at the close of the second year's growth measured 2½ inches. As the man standing by the tree measured 6 feet, 3 inches, to the top of his hat, the reader may get some idea of the remarkable growth of these trees. There is no reason why they should not have made this remarkable growth, for, although we experienced a continuous dry period with the excessive heat of 100 degrees and above for 43 days, from June 18 to August 1, entirely without rain; yet during that entire time the ground was amply moist to make into balls about the roots of the trees, and to a depth of over 10 feet. During this entire time, owing to the manner of cultivation and the care taken to save the moisture, this soil was practically as full of moisture about the roots of the trees as it could hold, and had there been previous irrigation from a ditch the soil could not have been more moist.

In cut No. 14, is shown a white elm tree. Looking closely you can see the man's hand about four feet from the ground, grasping the pole which

Cut No. 14.

is ten feet high. At this point where the hand shows, the tree was cut off when set in the spring of 1900. The growth during 1900 was not much, though quite as much as might be expected the first year, the new limbs averaging about ten inches. This photograph was taken August 23, 1901, when the tree reached within eight inches of the top of the ten-foot pole. October 1st, thirty-eight days later, this tree stood two inches above the top of the pole. Elms are usually considered slow growth. This illustration is certainly a demonstration of two facts, that they will make remarkable growth with plenty of moisture, and that moisture can be stored in sufficient quantities on the far western prairies to supply all necessary needs of such trees.

In the setting of trees or orchards in the more arid portions of this belt, care should be taken not to get them too close together. A successful growing of a tree depends upon ample pasturage of the root. In our orchard at the Model Farm we set our cherries and peach trees 22 feet each way, and our apples 22 by 32 feet. No crop of any kind or nature should be grown in an orchard if you would secure the best results. It may seem like a waste of ground to see little two-year old trees standing 2½ to 3 feet high, with tops only 1 foot to 18 inches broad, 22 feet apart each way; but when we note the immense growth of our trees the second year we see it is not long before the entire space is utilized. Back of our house where we live in Holdrege, Nebraska, is a cherry tree that now measures 17½ feet across from tip to tip of limbs. You can readily see that in the 22-foot distances we only have 4½ feet left. Now if you expect the trees to make this growth you must not interfere with the roots of the tree, or in any way rob it of any of the moisture or plant food in the soil. Besides, to plant a crop of any kind would make the cultivation much more inconvenient and expensive. A trip back to the old eastern states, even in Illinois, and then on through Ohio and New York state, will disclose a radical change in methods of handling orchards. The most profitable orchards in those states, to-day, have no crops or grasses growing in them; while twenty years ago it was a common practice to seed them down to grasses. If that kind of treatment is desirable and profitable in the east where the rainfall is more than abundant, it is much more desirable in the west.

To more clearly bring out the marked contrast between ordinary care and cultivation of orchards we secured cuts Nos. 15, 16, and 17 through the kindness of Prof. Hillgard, of the California Agricultural College. Cut No. 15 represents a prune orchard in California that has received good care and cultivation, trees are perfectly healthy and carrying a heavy crop of fine well developed prunes. Cut No. 16 represents another prune orchard adjoining No. 15 and separated only by a public highway. This orchard was carelessly cultivated, as is common with men who know nothing of the principles of storing water in the soil by cultivation, and is reported to have remarked to the owner of No. 15 that it was a waste of time and

money to cultivate so often, that if it was a year for prunes he would get prunes, if it was not then he would not be out much expense. The only difference in the two orchards this particular season was the time and manner of cultivation. Immagine the surprise of the owner of orchard No.

Cut No. 15.

16 when harvest time came. In cut No. 17 is shown a like contrast in the size and quality of the fruit as each orchard has its representative pile of fruit. The difference in the quantity of yield was much greater than is shown in the size. These three cuts are given to show results of actual tests with reference to storing and conserving the natural rain waters in

the soil by proper cultivation, and its effect upon the growth and development of the trees and their fruitfulness. The contrast in results here are no more marked than they are in cuts 12 and 13 representing a single years growth of our peach trees, but they not only substantiate our claims as to

Cut No. 16.

the cause of this marvelous growth on the Pomeroy Model Farm but that the same results may be looked for in fruit when our trees reach the proper age. What is true in orchards is equaly true in the raising of all kinds of grains and vegetables, it is the simple question of ample supply of available water at all times during the growing season.

Fruit taken from Trees shown in Cut No. 15. **Cut No. 17.** Fruit taken from Trees shown in Cut No. 16.

SPRAYING FOR THE CODLING MOTH

In Southern Nebraska, the codling moth may be expected to come forth and deposit its eggs from the first brood, between the 10th to the 20th of May. Some few belated moths that have hibernated in cool locations may come later. Under favorable conditions some may come earlier. As a rule they do not come forth until a number of days after the apple orchard is in bloom. It requires a considerable amount of warmth to tempt them from their hiding places. Their eggs may be deposited on the foliage or on the fruit itself. The eggs usually hatch in about eight days. As soon as hatched these minute larvae hasten to get under cover, or out of sight. Instinct leads them to get inside the apples as soon as possible.

Some careful observers estimate that 80 per cent. of the larvae that enter the apple select the base of the calyx. It is on the possible chance of placing poison in the calyx of the apple before the larvae selects that as a hiding place, that our present method of combating the codling moth is founded. The orchardist attempts to spray before the calyx closes so that particles of poison may be deposited in the calyx not only before the larvae selects that point for entrance, but before the calyx is so tightly closed as to make it unlikely that the poisonous spray will be lodged therein.

There is no advantage in spraying while the trees are in blossom, since that is quite a number of days in advance of the appearance of the larvae. Spraying at that time is also dangerous to bees; and the man who cares nothing about his own or his neighbor's bees should also remember that if followed by a rain the poison would almost certainly be washed out, and, also that the poison used is believed to be detrimental to the delicate stamens and pistils of the blossoms. On the other hand, should heavy rains or press of work delay spraying until the calyx is tightly closed or until the apple turns downward, the poisonous spray is not likely to be lodged in the calyx.

Should the orchardist fail to destroy the major portion of the first brood of the larvae, his next method of attack is to trap the larvae when they hide. This effort should be made from the middle of June until the middle of July.

In the last five years many orchardists have remarked that they did not see enough difference between orchards sprayed and those not sprayed to justify the trouble. Many made no effort to spray, and some years found their fruit reasonably free from worms. This varying experience may be accounted for by the fact that the close attention to details required in successful work has not always been given. Successful work requires a

suitable pump and apparatus. A selection of some insecticide of known strength.

Many of our orchardists are now using arsenical preparations, that is, Paris green, London purple, green arsenoid, or white arsenic combined with salsoda, with a Bordeaux mixture. The lime in the Bordeaux mixture assists in guarding the foliage from being burned by the arsenic.

Should the orchard be infested with the tent caterpillar or canker worm, spraying for the codling moth destroys all of the leaf-eating insects that happen to be at work at the same time. Since the codling moth do not all come forth at the same time, there is a variation in the number of apples in bloom, and in condition of the apple to be protected. It is therefore considered wise to spray the second time about ten days after the first spraying. After this second spraying in May it is an open question whether spraying against the codling moth in June has much value. The orchardist resorts to other methods which may be discussed later. The varying results secured in the attempt to destroy the larvae of the codling moth may be due to lack of knowledge, and suitable preparation, care and methods. Perhaps some suggestions may be useful:

First, it is well to have a suitable pump and nozzle. The metal parts of the pump that come in contact with the solution should be brass. Our old pump operated by horse power troubled us a good deal for lack or this necessary feature. It required repacking frequently, and we had a good deal of trouble with it to keep it in order. The pump we are using this year has its working parts which come in contact with the poison, made of brass. Having a large amount of spraying, we will, as we have for many years, use a two-horse power pump. The pump should have a good agitator, one that will keep the contents of the barrel continually stirred, that the liquid may be even in quality, otherwise the portion in the top of the barrel or tank will be weak, that in the lower part have such an excess of arsenic as will burn the foliage. The pump must have great force or power. The liquid must be applied as a fine mist. A fine mist will cover and remain attached to everything with which it comes in contact.

Most orchardists now endeavor to accomplish as much as possible with one spraying. The Bordeaux mixture combats possible fungus spores. The poison intended for the larvae of the codling moth also destroys leaf-eating insects in addition to destroying many of the larvae of the codling moth. Thus three lines of work are accomplished with one effort. Should the Bordeaux mixture be omitted, it is wise to use lime in the proportion of at least two pounds of lime to each pound of Paris green, London purple, or green arsenoid. More lime can do no more harm than the difficulty of passing a large amount of lime through the nozzle.

To secure a fine mist the spray must be broken up very fine. If the lime is improperly slacked small particles may be left in the solution, which are likely to clog the nozzle. It is also well to be careful not to dis-

solve the sulphate of copper in a coarse sack. To dissolve the sulphate it should be suspended in a bag composed of cloth that will not shed lint. It will dissolve more quickly in hot water. A stock solution may be made. That is, where ten kerosene barrels of water are to be used, forty pounds of the sulphate may be dissolved at one time. One-tenth by measure, may be taken for each barrel of water. This amount may be used for each fifty gallons of the Bordeaux mixture. The lime must always be slacked separately.

To secure the most complete slacking of the lime, it is well to use the plan followed by masons in preparing for hard finish, using enough water so the lime is at all times covered with the water and kept from the air. This would mean about twenty-four quarts of water to be used in slacking four pounds of lime. After slacking, it would be well to run it through a fine copper seive, stirred to remove all the coarser particles which would clog the nozzle.

The sulphate of copper and the lime should be mixed only a barrel or a tankful at a time, since some chemical change takes place in a short time rendering it less effective. In mixing the Paris green, London purple, or green arsenoid, the proper amount of poison should be put in a bowl and a little water added, then stir and gradually add water until you finally have a thin paste. Add this to the Bordeaux mixture last of all since it has a tendency to settle in the bottom of the barrel or tank.

It is important that the tank or barrel should be tight. It would be found disagreeable to be wet or slopped either with strong arsenical poisons or Bordeaux mixture. It should be carefully remembered that the operator is handling very strong poison and he should guard himself during the use of it as carefully as possible. The operator will find it much easier to spray with the wind than against it and that it is more convenient if possible to spray when there is little wind. The operator should also remember that if heavy rains follow soon after spraying, the work is lost.

With a horse power machine the expense for labor in spraying per acre does not exceed 60 cents. With us the cost of poison for the season, using both Bordeaux mixture and green arsenoid is estimated on 80 acres at about $80.00, or not more than $1.00 per acre. This does not reckon the cost of wear and tear of machinery. We would regard it as wise to supplement the work of spraying by efforts to trap the larvae which escape the poison from spraying. The larva after attaining its growth in the apple either falls to the ground with the apple and then seeks some hiding place to pupate or if the apple remains on the tree, leaving the apple crawls down the branch and limbs seeking some possible shelter from the birds. Should it find a loose scale of rough bark it may hide under this. Making use of this instinct of the larvae to get under cover as quickly as possible, many orchardists have found very beneficial results in banding the trunk of the tree with burlap or heavy paper, this in strips 8-10 inches in width

tacked on furnishes a shelter under which the larvae whether coming down or crawling up the tree find shelter from the birds. The larvae remains sheltered here during the period of pupating. Examining these bands once in seven or eight days, the orchardist destroys either by crushing or by throwing the bands into hot water and then replacing the bands. This work should be begun as early as the 15th of June and continued until the first of September. The successive broods of the codling moth overlap one another. In Nebraska and Kansas we always have at least two broods and these broods overlap one another in such manner that it is necessary to be on guard against them from the middle of June until the first of September.

The early summer apples are more likely to escape than the late winter, because it seems easier to destroy the largest portion of the first brood than to hold sufficiently in check by spraying the second brood. This makes the supplementary work of trapping the larvae by banding the tree, a decided help in the work of combating the codling moth. Those who are particularly interested in the work which has been done by the members of the State Horticultural Society in the work of holding the codling moth in check should read recent reports giving an accurate account of the codling moths destroyed at each catch, and during the entire season by orchardists who have followed this method and taken the time to count and report results secured.

These may be secured by addressing the Secretary of the State Board of Horticulture of Denver.

E. F. STEVENS.

THE PRUNING OF FRUIT TREES UNDER SEMI-ARID CONDITIONS.

My early training was secured in the State of Maine where it was considered good form to open out the head of the tree to let in the sun and to grow trees with high bodies that a horse might drive under them.

Under the climatic conditions in that state trees may live to be 75 to 100 years of age. At a later period living in California other conditions were met. Different methods of pruning adapted to their conditions had to be studied. Located 30 years in Nebraska we find conditions differing from either; that the pruning adapted to New England or California is not suited to the semi-arid belt, and methods considered good form in the extreme eastern counties of our state are not suited to the semi-arid conditions of western Nebraska and Kansas.

Under semi-arid conditions we can not expect trees to be as long lived as in New England. Our effort should be to bring trees into bearing at an early age and to secure the best possible results during the first 20 or 25 years of the life of the tree. We may have destructive hail storms.

We have the rapid evaporation incident to many sunny days of the heated periods of mid-summer and not infrequently of parching dry winds. We may have late spring frosts. To guard against hail, head the trees very low within 12 to 18 inches of the ground. If the trunk can be protected by the head of the tree no matter how seriously the limbs of the tree may have been damaged by hail, a new tree can be grown from the sound trunk.

Mr. J. W. Hogg, one of the most successful growers of the apple in western Nebraska, prefers to head his apple trees to within 12 inches of the ground for the reasons above suggested. This gentleman grew something more than 1200 bushels of apples during the season of 1901 and quantities of other varieties of fruits. We must also guard against sun scald which is liable to damage the bark on the south and west sides of the trunk of the tree, and thus invite the attack of the flat headed borer. If in planting we set the best branched side of the tree toward the south, and grow the tree with a spreading head with an abundance of foliage, the tree soon shelters itself against sun-scald. It is not considered good form to open up the head of the tree since that would lead to sun-scald of the principal branches and limbs. It will also be noted that following light hail the fruit in the interior of the tree often times escapes when that on the outer branches is damaged. We think it is also true that during the frosty nights of late spring the temperature may fall 4 to 6 degrees below freezing point and yet when shaded from the first rays of the morning sun the temperature rising and the frost being drawn out slowly, the fruit is not destroyed. Our habit is to head the apple tree in such form that when loaded with a full crop the lower branches rest on the ground and quite a portion of the fruit of the tree can be picked from the ground. The tree suffers less from violent winds, less fruit is blown off. In the eastern states a crop of apples grown in this way might not be sufficiently colored. In the semi-arid regions we have a super-abundance of sun light and need not fear for the ripening and coloring of the fruit on the lower branches. We think it is now conceded that in the trimming of the apple tree for semi-arid regions, little more is required than to leave a very low head and to remove such branches as would cross or interfere with each other in the after-growth of the tree.

The cherry requires very little trimming. A low, full head removing only such branches as cross. Where a very heavy growth had been secured by superior cultivation we have found it better to shorten the ends of the branches and thus induce a larger number of branches and twigs. To grow a maximum crop of cherries requires many branches and small twigs.

In the growing of the peach many of our largest orchardists now select small trees, not over two to three feet in height, that the trees may be more likely to head low, resulting in less damage from the wind and that the major portion of the fruit can be picked from the tree, the picker

standing on the ground. In planting the peach it is better to cut back the branch to within one to two buds of the trunk and to endeavor to head the tree within 8 inches of the ground. We are often asked regarding the value of trimming in late August or September, that is, cutting off the ends of the shoots to induce early ripening. Apparently there is very little in this. The most successful growers of the peach do the needed trimming in the month of March, while growers in Michigan regard it as wise to grow an open head to admit the sun-light and air, and this aids in thinning the fruit, yet in western Nebraska and Kansas we should hesitate to trim the peach to an open head. We find in observing the behavior of a good many trees that the peach tree with the open head suffers more from hail storms, to which we are liable, and apparently would suffer more from the late spring freezes. Our liability to late spring freezes is such that we should hesitate to thin out the amount of fruit in the tree by trimming in advance of knowing what the spring might bring forth and would prefer to thin the fruit as needed at a later period rather than risk the thinning of the fruit in March.

In handling of the grape vine we would regard it as of decided advantage to trim in early November and to cover each and every vine before winter.

In the pruning of the shade trees it is neither wise nor safe to trim to a high trunk aiming to secure high headed trees during the early years of growth, but rather plant with lower heads removing the branches gradually and giving heigth of trunk only as a broad head has been developed that should secure the most vigorous circulation of sap, and the necessary shade of trunk. Excessive pruning at any one time is a serious shock to the tree and lessens root growth and development of trunk and head. The aim should be at all times to carry the most abundant foliage possible since large leaf growth coincides with corresponding root growth and the vigorous building up of the tree. To guard against the splitting off of the important branches by violent winds, head trees so that the principal branches come out at intervals and never two branches of quite equal strength at the same point. The tree can easily outgrow the loss of small branches and if the branches of the tree are guided as suggested there is not likely to be much loss from the splitting out of large branches.

E. F. STEVENS.

Crete, Nebr.

ARBORICULTURE.

ITS VALUE AND IMPORTANCE.

BY J. STERLING MORTON.

Mr. H. W. Campbell, Holdrege, Nebraska:

DEAR SIR—After an experience of more than forty years at Arbor Lodge, adjoining Nebraska City, in the County of Otoe, I declare that the best method of planting forest trees is in rows running north and south. The first row on the east should be of a rapidly growing variety, like catalpa speciosa, cottonwood, aspen, or soft maple. The next row should be a nut-bearing tree, like the black walnut, butternut, or coffee bean. The next succeeding row on the west should be, like the first one, of a rapidly growing variety. Planted in this way, the swiftly growing trees act as nurses for the slowly growing trees. Planted thus, black walnut, instead of putting on a scrubby growth and looking like gigantic quince trees when they have reached twenty years of age, run up towards the sun for light and make good trunks of twenty feet in length. This wood is valuable, and trees thus planted are grown with relative celerity. At Arbor Lodge I have between 100 and 200 walnuts thus treated, which were put into the ground in the autumn of 1865, and if you could see and measure them, it would be a work of supererogation for me to make further argument in favor of this system of planting. To grow either deciduous trees or any variety of conifers on these plains with any degree of success, it is necessary to plant them close together. All great forests, whence have come the best timber that man has ever used for building and cabinet woods, have been dense. The vast pineries of the Northwest were so closely planted by nature that it was impossible for a horseman to ride through many of them because of the interweaving branches. To successfully grow trees like those the forests produced, we must endeavor to create forestal conditions.

In 1892 I planted out 10,000 white pines, purchased of Robert Douglas' Sons at Waukegan, Ill. They were two years old and averaged perhaps a foot to 14 inches in height. They were planted in rows 4 feet apart, and the trees were 4 feet from each other in the rows. They were cultivated three or four years with the plow, the same as corn is cultivated, the furrows going first east and west and then north and south. They have made a remarkably fine growth, both as to height and circumference. Many of them are from four to five inches in diameter and from 18 to 20 feet in height. It is with difficulty that a man can walk among them, and last summer when the drouth and hot winds were doing their worst to

smother and parch out vegetation in this section of the country, those pines showed no indication of distress. Going in among them and stooping down, and looking under their lower limbs, one could see not a single particle of vegetable growth aside from the trees. The ground was thoroughly mulched with the needles which had fallen from them, and blanketed the earth, so to speak, with the mold which they had created. Removing this carpet of needles one could find moist, cool soil at all times. The conditions about the roots of these trees were such as their ancestors found in the great pineries of Wisconsin, Minnesota and Michigan. Many varieties of trees have been condemned as unfit for cultivation in Nebraska, after trying them in isolated positions, exposed to the hot sun and drying winds from the southwest. Trees are almost as gregarious as human beings. No man or woman could have been perfectly developed, physically and intellectually, in absolute solitude and without communication or intercourse with other human beings. And just so, no single tree planted out on the hot prairie, exposed to the burning sun all day long, can make as perfect a specimen of its kind as can be grown where trees are clustered together.

Arboriculture is absolutely indispensable to the conservation of other plant life, and even to the existence of animal life on these plains. The interdependence of the lives of trees and the lives of human beings is constant. If a single summer should be passed without foliage, flower or fruit on the globe, all animal existence would cease.

Your great work in soil culiure is thoroughly appreciated by every thinking citizen of Nebraska. Your intelligent efforts to benefit the agriculture and horticulture of this state are of greater value to your race and to those who come after you than all the efforts of all the members of congress who have ever represented this commonwealth at Washington. It is a gratification to realize that soil culture and arboriculture are destined, without asking an appropriation from the general government, to revolutionize the climatic and productive conditions of the state of Nebraska. Just as plants need light and as potato sprouts in dark cellars seek the windows and doors where the sun's rays occasionally stream in, so all the people of the prairie states need the illuminating practicalities of your researches and experiments in soil culture, which illustrate the method of insuring crops by intelligent tillage against destruction by droughts.

ARBOR LODGE, Jan. 18th, 1902. J. STERLING MORTON.

SUGAR BEETS.

The cultivation of the sugar beet is worthy of considerable attention among the farmers, outside of the question of growing them for the sugar factory. With the careful preparation of the soil, which should differ in only one respect from that which we have outlined for other crops, and

Cut No. 18.

that is deeper plowing, but the same care taken in thorough pulverizing, and in the more arid portion thorough packing, large yields may be secured. Cut No. 12 shows a field of sugar beets grown at Lisbon, North Dakota, on the grounds of the Soldiers Home, under the direction of Colonel McIlvaine, in 1897, the second year's experiment on the same ground, under the so-called Campbell Method of Soil Culture. The phenomenal yield of 46,000 pounds per acre was secured, or 23 tons. It may be readily seen from this illustration the vast amount of valuable feed that can be raised

from a very small piece of ground. The question of the manufacture of beet sugar has received no little attention in this country during the past ten years, and considering the wonderful results that have been attained by feeding beet pulp after all the sugar has been extracted, is a strong argument in favor of the growing of these beets by all farmers. To one who has not raised beets or other garden vegetables, except in little plats for domestic use only, it may seem like a very tedious job and quite expensive. But this is not true. With a fine toothed cultivator and by drilling the beets in rows 2½ to 3 feet apart, almost the entire work can be done with the horse, requiring a little hand work in thinning. Here, too, some surprising results can be attained. In the extreme northwest portion of Kansas, only 28 miles from the Colorado line, in 1898, we raised as fine beets, parsnips, turnips, carrots, and onions, as any man ever saw on the high level prairie, with very little work, except what was done with the horse and cultivator. The average farmer in that section did not believe it was possible to raise garden vegetables, and little attempt to raise them had been made for some time.

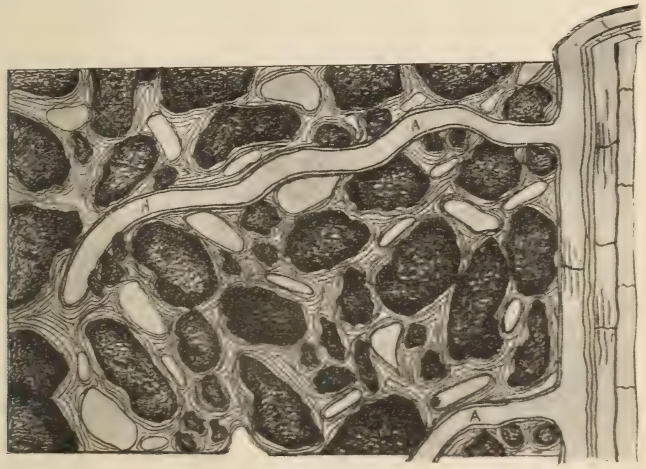
Sugar beets have been fed to sheep, cattle, and hogs in experiment at many of our agricultural colleges, with other feed, always with good results, especially in feeding sheep.

That sugar beets may be made to yield enormous crops by the Campbell method of utilizing the rainwaters, is clearly shown by Cut No. 12, showing a field of these beets grown on the Soldiers Home grounds at Lisbon, North Dakota, by Col. W. W. McElvaine's diligent efforts in carrying out our instructions in 1897, the second year of work at this point. It being one of the five experimental farms that was started by the Northern Pacific Railway in 1896, under our direction. Equal results may be secured on almost any of our level prairies of the semi-arid belt with the same care and attention, not only in sugar beets, but all vegetables. In this work, as in field work, it is not so much the additional or extra work, as it is the care as to time and manner of doing the work.

GROWING POTATOES.

The growing of potatoes throughout the semi-arid belt seems generally to be looked upon as too uncertain to even be considered, in spite of the fact that there are many individuals who are raising them and yearly making money. There are instances even in sections of southern Nebraska where they were less favored in 1901 with spring rains than in most any other portion of the state that good crops were grown. In one instance over

100 bushels of choice potatoes per acre were raised on a twenty acre field and were sold for an average of one dollar per bushel, the entire work of the season being done in line with our system of cultivation. The potato is a little different from any other crop and requires close attention during certain periods of its growth. There is no reason why good paying crops of potatoes may not be grown every year at almost any point from Canada line to Oklahoma, barring the ravages of insects or leaf blight, both of which are usually easily controlled by close attention and the use of proper remedies.



Cut No. 19.

PREPARING THE SOIL.

To secure a good crop of potatoes much care and attention must be given to the preparation of the seed and root bed. A glance at cut No. 6 shows the ideal condition. This soil was plowed eight inches deep after having been thoroughly disced to a depth of fully three and a half inches; the discing having been done early our soil was moist and was in the best possible condition to plow; as the furrow rolled over the fine, dry top soil went under, the moist soil coming to the surface in an ideal condition, and while moist the particles seemed to readily separate one from the other and adjust themselves without material resistence to the desired compactness, as the packer wheels rolled over the plowed ground, which was done quite close to the plow. While we have said much upon the importance of a proper condition of the soil when all work is done, we must almost repeat

it again, because so very much depends upon this to secure fineness, firmness and moisture in the soil such as may be most favorable to a rapid and full developement of roots such as will lead them to permeate every part or portion of the soil as shown in cut No. 6. In this, however, only the main lateral roots and branches are shown. The little hair roots or feeders may be found in such soil running in every direction, so completely filling the soil as to draw moisture and plant food from every portion. In cut No. 19 we illustrate a condition that should be well understood. It represents at the right a section of a branch root showing the cell formation; from these outer cells are the hair roots or feeders, A A, running through among the particles of soil represented by the dark spots; around these spots are lines parallel with the shape of the particle of soil which represents the film or covering of water. The white spots represent air spaces. Now, if the reader will look at this cut and think for a moment that these hair roots or little tubes marked A A in their full size in the soil are barely perceptable to the naked eye, and then imagine that these soil grains and air spaces here shown are proportionately smaller in their real soil condition, he can catch the ideal condition as shown in cut No. 6.

If you are after a sure crop, as well as a good crop of potatoes, get your root bed as near this condition as possible. Now, having previously succeeded in storing a liberal amount of moisture in the soil below, as shown in Cut No. 8, you can plant your potatoes knowing you have done all you could do to assure success so far.

Planting may be done at the time of plowing by dropping the potatoes on the side of the furrows about 3 inches from the bottom, letting the next furrow cover them; or complete the fitting same as for any crop and then plant with a potato planter about four inches deep.

SEED.

As to variety and quantity of seed, we favor the well-bred early Ohio, and prefer large potatoes and cut them as near to two eyes on a piece, putting one piece in a hill. For the more arid portions of the semi-arid belt we would plant the rows about 3 feet 10 inches apart and drop the seed, cut as above, about 20 inches apart. In the lower altitudes, or where there is a greater rainfall, plant somewhat closer. Remember, the one great point is to never let your potato plant lack for water. If you do your crop suffers. Small and knotty potatoes are the result of the potato plant getting short of water at certain times, which tends to force the ripening or maturing period. Then a sudden and heavy rainfall or the irrigation of the potatoes after this condition forces a new and rapid growth which results in setting a second lot of potatoes, some of which may appear on the roots and others on the sides of the already formed potato.

CULTIVATION.

With your crop in the ground under favorable conditions, then comes the important work. There is no better tool in the early cultivation than the harrow or weeder if you will use it freely and with some judgment. The long toothed weeder may be used from the time the crop is planted until the tops are too large to draw through between the teeth, providing you catch the soil in just the proper condition, especially in the average sand loam soils. Should you get a very heavy rain that may result in packing the surface to a considerable depth, then it will be necessary to cultivate with some fine tooth cultivator, as in cultivating corn, but in such a case it is well to follow the cultivator closely by crossing the rows with the weeder. This more completely fines the mulch as well as levels it, also loosens the soil among the vines and cleans the young weeds. Watch closely the condition, however, and be sure to keep the soil stirred deep enough, even if it is necessary to use the cultivator; a mulch of fine, loose soil of fully two and a half inches in depth should be kept as soon as the potato tops get to any size, and the soil should be stirred often enough to keep the top of the firm soil beneath the mulch in a moist condition. This condition can be kept if you have moisture stored below and do not plant too thick and watch your time of cultivation. Upon the care and attention given over to this part of the work depends the quality and quantity of your crop. Don't stop cultivation when they are in blossom, but don't destroy the roots. Try to carry through the condition as near as possible as shown in cut No. 6.

ALFALFA.

Alfalfa, like all other crops, thrives best under the most favorable conditions. There is probably no point in the raising of alfalfa more important than that of securing a good stand. It seems almost impossible, in fact climatic conditions must be very favorable, in order to get a catch of seed in reseeding spots among well rooted plants. There is no seed that responds, or returns greater rewards for a good seed bed than alfalfa, and yet it is a very simple proposition, and if the proper course is pursued and good seed used there is practically no question about securing a good stand. On the high divides in many localities in Nebraska and Kansas alfalfa is being raised quite satisfactorily, the only difficulty generally being an uneven stand. The summer culture plan by which one season's rain is stored in the ground, and the soil carefully prepared as outlined in

the chapter under this heading, then sowing the seed the following spring, taking care to loosen the surface soil the first opening of spring is best for securing a good stand of alfalfa. The best results I have ever seen in Western Kansas have come from seeding early in April on ground thus prepared, with ten pounds of seed put in with a shoe drill with a chain cover. At the time of seeding there was about two inches of loose, fine soil on the surface made by the use of a common harrow, and the shoe set so as to put the seed from one-half to one inch into the solid, fine, moist soil beneath. The seed came up quickly and very even, and if there was any complaint to be made it was the fact that it was too thick. With the prevailing price of alfalfa seed the saving of a few pounds of seed is a great item, especially in putting in large fields. The further fact that when once sowed and the crop established it is there for years to come, certainly is sufficient argument to support the demand for thorough and careful preparation of the seed bed. The summer culture idea involving this storage of one year's rainfall puts the soil in such condition for five or six feet down that the tap root immediately pushes on down through this moist soil sending out the little feeders on their way down, and the chances are that a good crop may be harvested the first year, as was true in the case above referred to, due only to the fact that the soil conditions were perfect for the rapid development of roots, and ample moisture to produce this magnificient growth. While it is true that much better results are attained from alfalfa in valleys where sheet water is 8 to 12 feet from the surface, yet a sufficient number of experiments have been made and in some of them a sufficient length of time has elapsed, to warrant the statement that on the majority of our high divides in the semi-arid belt as good or better yields can be secured from this crop than are commonly harvested in the eastern states on the average meadows of timothies and clovers. The value of lands where the phenomenal crops or yields of alfalfa along some of the valleys in Western Nebraska and Kansas has hardly come to be understood, or fully appreciated even by the people who have raised them. We are familiar with fields that for three successive years have turned off in alfalfa hay alone from $30.00 to $40.00 per acre net profit over and above expense of harvesting, and where hay and a crop of seed has been harvested as high as $80.00 net profit per acre has been made. The value of this plant for feeding hogs, cattle, and sheep is just beginning to be appreciated. All experiments thus far carefully conducted have demonstrated that there is no fodder plant so valuable.

The fitting of fields for seeding to alfalfa on old ground cannot be better explained than the instructions under the heading of Summer Culture for spring wheat. But if the reader must sow without giving the year's cultivation and storage of water, then keep in mind two fundamental principles, viz.: plenty of stored moisture in the soil below and a fine, firm seed bed. There is enconomy in these, as you can not only get a

better and more even stand with much less seed, but your chances are increased many fold for getting a good stand regardless of what the season may be.

SEEDING ON NEW BREAKING.

Alfalfa, like many other crops, may be sowed on new breaking the same season the breaking is done and sometimes get satisfactory results, but considering its uncertainty and the difference in the value of a good crop as against a poor crop and possibly none at all, we are inclined to give over the whole season to fitting, for a good crop is then practically assured.

Breaking should be done when the grass is growing the fastest, for at this time the sod seems to more readily and more completely rot. Let the plow run about two and one-half inches deep, using every possible means and care to lay the furrow slice flat and roll down solid either with the packer or a disc set straight, then harrow; here again the Acme harrow comes in with good results, the object being to loosen enough dirt from the sod to fill all the crevices between the furrows and form a perfect blanket to hold all the rainfall down under the sod, then take care of the big rains by harrowing again. If this is fully accomplished the sod will not only be fully rotted in a very short time but the top of the subsoil beneath will also become rotted to a depth of two to three inches. As soon as this is found to be true, then begin backsetting or plowing with the stubble plow, cutting about two and one-half inches deeper; follow the plow with the packer as explained under the heading of Plowing and Sub-Packing, then follow with the harrow, the Acme preferred, getting it all fine and firm before it has time to dry out. Look well to the storage of later rains and be ready to loosen the surface in early spring with the harrow and put in your seed fairly early, governed largely by the locality, using not over ten pounds of good seed with a shoe drill and chain cover. If your work is all well done, as outlined, you need have no fears of the result.

BARN YARD MANURES.

It needs no argument to prove to the eastern farmer in the more humid sections of this country, that there is great value in the use of barn yard manures. In fact, in most sections of the east every opportunity possible is utilized in increasing the quantity. In the west, or more especially in the semi-arid belt, farmers have come to look upon this question in an entire different light. Probably in the entire belt at the present

time a much larger per cent. of these manures are either thrown into a draw or burned up. This is all wrong. There is no section of country where the soil would respond more liberally and for a longer period of years after the application of manure than here. The difficulty lies in the manner of applying. The dryness of our atmosphere and the frequent long periods without rain is not conducive to nutrication or decomposition, consequently in our early experiences in applying it to our fields, more or less straw and coarse matter in almost a perfect state of preservation had to be used. With our light, loose, loamy soil there is not sufficient weight to press this coarse matter down solid when plowed under, consequently the open porous condition underneath, the detrimental effect of which is not well known, resulted in burning the crop and producing weeds. We have met with the best results by spreading the manures on the surface, evenly as possible, then with a sharp disc double-disc the surface, mixing it to a considerable extent with the top three inches of soil, then plowing six or seven inches deep, using a rod on the beam to turn everything under, following the plow with the sub-surface packer, which would result in compacting the soil and manures firmly in the bottom. With slight moisture under these conditions decomposition quickly takes place. In early experience in Brown County, South Dakota, in the year 1882, we applied a liberal coating of barn yard manure, plowed it under, and worked it down as best we could after the manner usually practiced in old Vermont. The rainfall during that season was quite liberal and timely. The piece, about five acres, was planted to corn and well cultivated, with such good results, that we decided to treat the manure question with the same care and economy as we were wont to do in the east. The same plan was followed out in '83, with a total loss of all the crops which were planted on that ground. A small attempt was made again in '84, with the same poor results. For several years after this we followed the usual plan of the western farmer, of hauling it out and using any possible method to get rid of it. But the remarkable results each and every year from the field where the manure was applied in '82, was too convincing of its value. For ten consecutive years this entire quarter section was put into wheat. Every year in the early stages of the growth of the wheat the shape of this five-acre field, which was in one corner of the 160 acres, was perceptible both in the color of the wheat and the development of the stools, and almost invariably at harvest time the grain on this little piece would be from four to eight and ten inches higher than the balance of the field, and yielded invariably from 50 to 150 per cent. more. With much study along these lines, and several experiments, to find out why such remarkable results were obtained from this field and why we could not succeed in later attempts, we were finally able to solve the problem fully. It is simply a question of mixing the manures into the soil as much as possible, and then firming the under portion of the furrow slice, thoroughly compacting manure

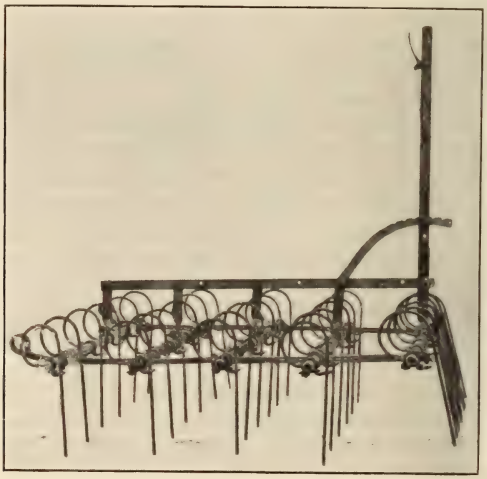
and soil, followed with careful cultivation, when the same results may practically be attained any year that were secured in the seasons referred to, when we had the unusual amount of rain scattered along at proper periods at just the right time to produce decomposition. The peculiarity of the formation of our soil is such that manures, when properly applied, very materially aid us in carrying our crops through the dry periods and preventing the serious effects of the drouth, for the simple reason that the humus, which is the complete decomposed vegetable matter, very materially increases the water holding capacity of our soil. The more humus we have in the soil, the greater is the number of particles, consequently the greater amount of surface to hold water. It also aids in the movement of moisture through the soil, and in the encouragement and development of root growth.

When barn yard manures are properly applied to the prairies of the semi-arid belt, their effect upon plant growth is noticeable much longer than in the east, where the greater rainfall has a tendency to wash the humus below. This trouble of washing out is especially perceptible in the gravelly soils of New York and the New England states There is another advantage of the semi-arid belt which will be appreciated when these facts are better understood by the masses, for our observations so far clearly show that manures are even more valuable here than in the east, not that our soil is not fertile, but the more humus we have in the soil the more water will each square inch of soil hold, and consequently the safer is our crop and less liable to suffer from drought. There is but little expense attached to an experiment to ascertain the correctness of our assertions on this subject, and were you to make them, you would find more and surer profit from them than from government bonds. The sub-surface packer is a very valuable tool in securing immediate results from manure. See cut No. 2. This shows how the manure would be compacted in the bottom.

THE WEEDER.

While the weeder is comparatively a new tool upon the market, it has come to stay. Its usefulness is found in many ways. In the growing of wheat in the great wheat country, the Dakotas and Northern Minnesota, the fields have become very foul. The effect of the weeds upon the yield of the crop is very detrimental. There is a time when the weed first makes its appearance that it is easily destroyed. This time in the spring wheat country is usually about the time wheat is stooling. Here the weeder comes in with its very effective work. The long flexible tooth as it

moves along loosens up the surface of the soil and easily destroys the young weeds, while if the root bed is fine and firm, the wheat has become quite firmly rooted and resists the tooth, which by its lateral flexibleness, slips around. Instances are reported where the harrowing of wheat with the weeder has more than doubled the crop. This is not at all remarkable, because we not only destroy the weed whose roots rob the roots of the wheat of their moisture and plant food, but we break the crust that may have been formed by the spring rains, loosening the surface, forming a mulch which prevents the evaporation of the moisture. Again in the cornfield and potato field we find its work most valuable. On the Pomeroy Model Farm, during the season of 1901, we took care of the corn almost entirely



One Section of the Combination Harrow and Weeder.

Cut No. 20.

with the weeder until the corn was fully 15 inches high, destroying the weeds completely around the stalks, while as the long flexible teeth approach the hills, the stalk, being firmly rooted, resists the teeth, and with its flexible lateral movement moves around the stalk without injuring it in the least, and yet completely destroying all the young weeds, loosening the surface, not only around the hills, but among the stalks. In the cultivation of potatoes we find it equally valuable, as it slips in among the potato vines, destroying the weeds in the hills and loosening the surface. It is also quite efficient in the orchard and in our summer culture work at times when only light rains fall, and do not result in packing our mulch very much, but sufficient to moisten it down to the solid soil. While

under these conditions the evaporation is not as great, yet it is important to stir the soil and dry it out. In this work, the weeder being light and easy of draught, does very efficient work. It is not an expensive tool, and to those who have not used it, it is worth their while for investigation.

Cut No. 20 shows one of the more recent construction of weeders, and like the later and newer inventions of any line, has its advantages over those of an older pattern. This is really a combination of a harrow with a weeder. These teeth, it will be noticed, may be slipped into a hook at the rear of the head. When in this position, as is shown on the four front bars in the cut, the teeth are 7½ inches long, and in this position is used as a common harrow, and as such does equally as good work as the old style steel harrow, both in pulverizing the surface and in smoothing.

When these teeth are released, as they are shown to be on the rear bar in cut, they are 24 inches long. In that position it is a weeder, with all the advantages of the common weeder, and in addition can be built much wider, even up to 32 feet wide, so that one man with six horses may go over 80 to 100 acres of wheat in one day. The position of the teeth may be regulated by the lever.

(See advertisement on another page.)

A WORD ON DRILLS.

We hear a good deal of discussion among the farmers with reference to the proper drills for sowing small grain. We think many farmers are very much misled in putting too much stress on the kind of a drill to be used. While in the semi-arid belt, if not in the entire great plains country, we believe the drill has many advantages over the broad cast seeder plan, yet the preparation of the ground, its physical condition, and amount of available moisture below at the time of seeding might almost be called the controlling condition as to the yield of the crop. If we are to admit that it will do to sow ground to wheat or other grain over and over again, two, three, and four years without plowing, then we might produce some argument possibly in favor of the disc drill or some other special drill. But the claim that a tool which will enable us to put seed into the ground without first properly preparing the ground is a question that should not receive consideration in this belt of country, and will not a few years later. Our preference at the present time, presuming that our ground is thoroughly plowed to a good depth, pulverized, and worked down firm with a loose mulch on top, is for the shoe drill with a chain cover, the object being to deposit the wheat about one inch into the fine, firm, moist soil, in a

narrow crevice so the wheat will come in contact with as much of the very moist soil as possible, and the object of the chain cover is to completely fill this little trench and yet leave the soil loose on top. This is the plan that we followed at the Pomeroy Model Farm the past two seasons, and the quick uniform germination and rapid growth and liberal stooling was simply wonderful. By careful observation we noticed this fact, that in seven days time from the time the seed was deposited it would germinate and grow six and a half inches in height from the kernel to the top of the first blade. If the reader will glance at cut No. 6 and notice the two inch mulch on top, the very fine firm condition of the soil underneath and think for a moment how perfect the condition is for the rapid development of the roots, both sides of where the kernel would lie, put in as we above stated, you can readily see the great advantage it has over wheat lying in a loose bed. While it is true that almost every drill has its peculiarities and possibile advantages in certain kinds of soil. Under certain conditions, it is quite an error for the farmer to conclude that he can materially increase his crop each and every year by any special construction of drill, but rather he should pin his faith to a proper and careful preparation of the soil.

We really do not believe the question of construction of the grain drill has as yet reached the point of perfection. The coming drill will be one of lighter draught and consequently wider cut, that will deposit the seed in firm soil without leaving the soil firm at the surface, like a wheel track.

RAPE AS A FORAGE PLANT FOR THE SOUTHWEST.

(By E. A. BURNETT, Director, Nebraska Agricultural Experiment Station.)

The rape plant has long been used as a pasture plant for sheep in England and some other European countries. It came to the notice of farmers and stockmen of the Central States some ten or fifteen years ago and has constantly grown in favor where late summer and fall pasture is important. At first it was thought that the rape plant could only be utilized in the more humid regions, but each year it has extended its western limit until at present it is a very important crop in the Red River Valley and over the entire spring wheat region of the Northwest. There it is grown mostly as a second crop after spring grain, but it is also grown to some extent as the main crop on the land where early pasture is desired.

It is a leafy, succulent plant, resembling a turnip, except that the foliage is more abundant, the plant growing from two to four feet high but producing no edible root.

VARITIES.

The Dwarf Essex and Victoria varieties are grown. They are of about equal value, but the former is rather more common. These varieties do not produce seed the first year. As they are killed by the first heavy freeze, they never produce seed in this latitude, all seed coming from Europe. The plant lives over winter in California and it is hoped seed may soon be secured from that locality. The seed can be secured from any reputable seedsman at a cost of about six to eight cents per pound, in lots of ten pounds or over.

A PASTURE CROP.

Rape is used only for pasture or soiling purposes. It cannot be cured for hay. As pasture it is best adapted to sheep and hogs, but can be used for cattle to advantage where there is a shortage of late summer and fall feed.

It can be sown in drills or broadcast in early spring, when it will be ready to pasture by early June. If sown in drills about two pounds of seed should be sown per acre with a garden drill, in rows twelve to twenty inches apart. The narrow rows may be cultivated with a wheel garden hoe, or the wider ones with a horse. After about two cultivations to kill the weeds, the crop will take care of itself and may be used sparingly for pasture when it is a foot high. If pastured when small and tender, animals bite off close and the root fails to send up new shoots, but later in the season, when the stalk has become larger and stronger, it may be pastured down the second or third time and will still come on for another crop.

SOWING THE CROP.

When sown broadcast without any other crop, as much as five pounds of seed per acre may be sown to advantage, as this thicker seeding helps to choke the weeds and cover the ground sooner than a thinner seeding. When sown alone the land should be well prepared by previous harrowing and discing to kill the weeds and store up the moisture in the soil. Sow any time from the middle of April to late in June, on well prepared land at the rate of about five pounds of seed per acre and you will soon have a fine stand and a splendid hog and sheep pasture which will last all summer long if not eaten down too closely.

AS A SECOND CROP.

In the states adjacent to Nebraska, rape is most valued as a crop which may be sown with grain in the spring and comes on after the grain

is cut. It can be pastured in the late summer and even into the early winter as it is not effected by ordinary frost and is only killed by severe freezing.

In Nebraska rape seed can be sown broadcast on winter wheat land at the rate of about two pounds of seed per acre. If sown late in April, or when the wheat is two or three inches high in the spring, and harrowed in, it will make a slow growth under cover of the wheat or rye and when the crop is cut will then come on rapidly if any moisture remains in the soil.

Rape may be sown with oats in the spring at the time of seeding, but it is better to sow broadcast when the oats are two or three inches high and go over the field with a smoothing harrow. This kills the weeds but does not injure the grain. It also covers the rape seed and, by breaking up the crust on the ground, saves moisture for the crop.

Rape may be sown in the cornfield before the last cultivation, and, if there is sufficient moisture to germinate the seed, it will often come on and produce fine fall pasture. This can be eaten off by lambs without destroying any considerable amount of corn. The lambs will eat the rape and the weeds and lower leaves on the corn but will not break down or injure the ears of corn unless they are lying on the ground.

RAPE A VALUABLE CROP.

In the states of Minnesota and the Dakotas the profit on the rape crop, grown as a second crop after wheat or oats, has often been equal to the profit on the main crop. Sheep, pasturing on rape sown in stubble fields, eat all weeds and scattered grain as well as the growing rape. They clean these fields of weeds so that the land is much cleaner for the succeeding crop than though sheep had not been there.

With a good stand of rape in a stubble field you can usually turn the stock on about three weeks after cutting the grain crop. Such a field will support ten or fifteen sheep per acre and keep them growing for six weeks. I have known many instances where sheep have produced one hundred pounds gain in weight per acre on rape in stubble fields. This gain was worth four or five dollars on the market and was clear profit. I have reason to believe cattle might be made to do nearly as well where rape was used to supplement other pasture, or where a little hay or straw was fed to neutralize the succulent effect of the rape.

CAUTION AGAINST BLOAT.

There is some danger from bloat in turning animals on rape pasture, especially if they are accustomed to it and eat it greedily at first. It is best to have prairie or tame grass pasture connected with the rape field or at first to have a feed rack with hay or straw accessible. It is also safer,

at first, to have the stock full of other feed, either pasture or grain, so they will not be hungry and eat too greedily. Some farmers practice turning their stock on the rape from other pastures and leaving them there only an hour or so each day until they become used to it. I have generally found little difficulty with animals put on rape for the first time, as they prefer other foods until they learn to eat the rape plant and seldom overfill.

RAPE COMES WITH INTENSIVE METHODS.

As we are endeavoring to secure larger profit per acre from our land, it is often necessary to take advantage of a catch crop to add to the profit and increase the stock-carrying capacity of our farms. Whether or not we can do this will depend on our location and amount of our rainfall. Experience has shown that rape as a catch crop, when pastured off, increases rather than decreases the fertility of the land. Experiments in North Dakota and practical experience on many Minnesota farms show a larger yield of grain following rape than where no rape had been grown. It also showed fields cleaner from weeds and in better condition to raise the next crop.

In Nebraska the wheat fields can be sown to rape and followed by corn without any loss of time on the crop. But a rape field could not be pastured and sown to winter wheat as we wish the pasture late in the season.

A SUMMER FEEDING GROUND.

The wheat and rape fields of Nebraska are excellently situated to intercept the range lamb as he comes from the range in August and September on his way to market. The range lamb is practically as heavy in August as in November. He can be fattened on the waste products of our Nebraska farms with little or no grain feeding and sent forward a finished lamb before winter sets in. This is being done with thousands of range lambs in Nebraska today and the business should be greatly developed.

The rape field may be exactly the thing needed to tide the farmer over with his cattle from summer to autumn pasture. It cannot be depended on as the only means of carrying stock through the summer but it is a valuable adjunct to good pastures and a great assistance in stock farming.

NOTE.—We are of the opinion that Prof. Burnett's idea of the rape field for the range lamb to cheaply and quickly fatten him in the fall months is a very practical one in any part of the semi-arid belt, and may be made one of certain success regardless of the possible dry mid summer and early autumn, by taking a piece of ground and proceeding precisely according to our plan for summer-culture, storing the moisture from early spring up to the middle of June, then plow and prepare land thoroughly, getting a fine, firm seed and root bed with a good soil mulch. Sow the

rape about the middle of July, having kept a close watch to store and conserve all rain waters up to sowing. The quickness with which the rape will germinate and the rapidity and rankness of its growth throughout the fall will be a surprise. We look for this plan to develop into large proportions because of its practicability and sure success.

SORGHUM FOR FORAGE.

(By PROF. A. L. HECKER, Nebraska Experiment Station.)

THE PLANT.

Sorghums, both saccharine and nonsaccharine, are too well known to need description, especially the saccharine which is grown in every state in the Union and familiar, no doubt, to every farmer of the Trans-Mississippi region.

The plant is supposed to be a native of central Africa and has been grown in this country some fifty or sixty years. This habit of rapidly acclimating itself has, no doubt, caused its spread and popularity.

Like corn it requires warm weather for rapid growth and does best on a rich, sandy loam, but will make a fair crop on nearly any kind of soil where crops will grow. Sorghum will stand much tramping which makes it a plant adapted for pasturing.

PLANTING.

There are many methods of planting in common use throughout the country, but the purpose for which the crop is intended has much to do with the method used.

Where the sorghum is grown for syrup or sugar it should be of a strongly saccharine variety and planted far enough apart to produce a good stalk. Plant like corn in hills and cultivate or list or drill in rows far apart.

For forage, sow broadcast from one to one and a half bushels per acre, harrowing in well or drilling in with a press drill. The amount of seed to use will depend on its quality and whether you wish a thick stand or not. When sown broadcast thickly it will produce a small stalk and must be harvested as you would hay.

Listing sorghum is popular in Nebraska and Kansas, especially in the western portions, where the rainfall is light and the soil rich and loose. Double listing is also practiced and thorough surface cultivating is, without doubt, the best method to grow sorghum during a drought.

The best sorghum crops grown in western Nebraska during the past few years were listed or planted in drills far enough apart to allow cultivating.

Where the crop is to be used for pasture or hay, sowing broadcast or drilling in thick is the best method and especially so in sections where rainfall is plentiful.

WHEN TO PLANT.

Sorghum seed like corn germinates best in warm earth not too wet and will do better planted after the corn rather than before.

It makes a good catch crop and under ordinary conditions will give a fair amount of forage on land which has grown a crop of rye or winter wheat.

The land in all cases should be well prepared and free from lumps and growing weeds.

The weeder should be used freely in early cultivation, as weeds should never be allowed to get the start of a sorghum field.

When once the sorghum gets a start no weed can ever get the upper hand, but on the contrary the sorghum will choke down everything.

HARVESTING.

When pastured it should not be turned on to until it reaches at least a two foot growth as the young plants will have then formed deep roots and will produce second growth.

Sorghum poisoning is still a mystery to science and is therefore difficult to cope with. However, we find it limited as a rule to certain districts which happily are few.

In sections where it is dangerous to pasture the sorghum, the wilted or cured forage has never been known to cause death, so the best preventive in this case is to soil or feed the cured fodder.

Where the crop is sown thickly in drills or broadcast it may be harvested as you would hay, cutting with a mower when the seed is in the early dough state. It should be left on the ground only long enough to wilt and partly change color when it can be raked up in bunches of half a ton each and then piled in cock to cure. Another method is to harvest with a reaper, allow to cure well in bundle, and then stack or put in barn.

When listed or drilled in rows, double or single, the best method is to cut with a corn harvester, the bundles are most convenient to handle and *will cure well.*

It may also be cut with a reaper, or corn cutter, when it should be shocked, as is common with Indian corn. A self rake reaper is sometimes used to good advantage. When in the loose bundle it will cure and may then be placed in shocks or long narrow rooks.

The seed production of sorghum runs from 20 to 40 bushels per acre, according to the richness of the soil and variety grown. To obtain the best seed the sorghum should be planted far enough apart to grow a strong, vigorous stalk. Seed may be grown from thickly planted cane, but it is of an inferior quality and will not weigh out or germinate like well developed cane seed, which is also much more valuable for feeding purposes.

If harvested in this method the seed can be easily threshed out, and is a paying crop for that purpose alone.

The yield of sorghum is a factor strongly in its favor, and one which puts it ahead of nearly any other plant. From 3 to 15 tons is the variable yield of cured fodder per acre, and on rich lands 7 or 8 tons can be counted on.

Where two or three cuttings can be made, as in some parts of the south, the yield runs up very high. It is a soiling crop of great value and can be fed to horses, cattle, sheep, and swine, with goood results. From its habit of second growth it will produce until killed by frost.

When cut in bloom it furnishes the largest amount of digestible nutriments, but is hard to cure at this stage. At the blooming period it is best to soil and makes one of the best foods to give dairy cows that are on poor pastures.

FEEDING VALUE.

In feeding value sorghum may be considered closely akin to corn, both in seed and stalk, the seed being a little less nutritious than shelled corn, while the sorghum forage well cured is better than corn stover.

While considerable investigating has been carried on by our Experiment Stations to determine the feeding value of this wonderful plant there is still much left for further investigation.

We know it to be a valuable forage for all kinds of stock, but little is known as to its digestibility in varieties and stage of growth.

The writer in co-operation with Prof. Lyons at the Nebraska Experiment Station tested for several years the pasture value of sorghum and other forage plants. In these tests we found the sorghum plant to furnish the greatest amount of pasture of any of the annual plants tested. A one-fifth acre plat will furnish pasture to one cow on full milk flow for one month. To get the best results when pasturing milch cows on sorghum a little feed, high in nitrogen, should be given as the young sorghum plant is strongly carbohydrate and weak in protein, while the high water percentage makes it difficult for the animal to get the required amount of protein.

Prof Burnett found in feeding sheep on sorghum hay in comparison with alfalfa that the latter gave much the better gains, but still sor-

ghum made a very good showing in his experiments. Sheep naturally are fond of leguminous plants and will do better when fed on a palatable ration. This might account for some of the loss in gain.

From time to time complaints have been made that sorguhum hay has a tendency to reduce the milk flow of dairy cows. The author has investigated a few cases of this kind and found, as a rule, the feeder had given his animals a ration of sorghum hay and nothing else, which is not to be advised in dairy cows.

The sorghum is often poorly cured, being sour, musty, or over dried, in which case much of its value is lost.

To feed sorghum hay and get the best results it should be balanced with clover, alfalfa, or cowpea hay. A grain ration may be given composed of bran, shorts, oats, or part corn, when fattening stock or feeding milk cows.

It is a palatable food and cattle will often leave the best tame hay for some well cured sorghum.

It is safe to say this great drought resisting plant should be grown much more than it is, and especially in the west.

Alfalfa is a grand feed, but like sorghum, it is better balanced than fed alone. With sorghum we have a forage cheap, drought resisting, nourishing and sure.

IRRIGATION.

It would hardly be proper to close our book without a word on irrigation, especially considering the fact that some have seemed to conceive the idea that our system was antagonistic to irrigation and that the promotion of this work generally would retard the development of irrigation enterprises, but this is far from true. The fundamental principle upon which the success of our system is based is the the economical use of water, it matters not from whence it cometh, whether direct from the clouds or from the flowing streams, ditches, reservoirs, or wells. The first and important thing is to get a supply of water stored in the soil to feed, nourish, and mature the crop in a period of dry weather, and the second, and almost equally important requisite, is the thorough preparation of the seed and root bed, so vital in the success of our system, all of which is nearly or quite as necessary in growing crops by the artificial application of water required by irrigation. We do not mean to be understood that a man may not get a better crop with plenty of water to turn loose at will upon a piece of ground poorly fitted than he could with the same reckless fitting and be obliged to de-

pend upon replenishing his soil with moisture from the heavens, but this is not the question today with the progressive farmer. It is how can we get the greatest results from our soil, labor and expense considered. In irrigation, water usually means money. There are few irrigation ditches today that carry enough water through the season to irrigate all the land that might be reached with water from the ditch. There are many fields that are made to suffer that are under the ditch and crops made light that if the principles involved in this book were understood and applied precisely as we outlined them to these fields, larger yields might be realized, and more acres covered with the same amount of water when the irrigator better understands the nature of plants and just what physical condition is best for the support of healthy roots and how they gather plant foods. Due consideration must be given to the roots of the plant and their necessary supply in proper quantities, not only of water, but of air also. Too much water at times is just as detrimental as too little water. A clear conception of how water moves in the soil is just as important to the irrigator as to the man who depends solely upon the rainfall.

The ideal condition for the most healthful and successful growth of all cultivated crops is a good depth of root bed made thoroughly fine and firm. There is little danger in getting the average sand loam soils, so common in the arid and semi-arid sections, too firm, while some of our heavy clay soils if not properly handled might become too closely compacted, but this kind of soil is not at all common. Previous to the thorough fitting of the seed and root bed see to it that ample moisture is stored below where nature can do her part by bringing it up to the roots of the growing plants by capillary attraction, then keep your surface always cultivated in such a manner as to provide as near as possible a fine, loose mulch of soil (not dust), stirring it often enough to keep the moisture up to the top of the firm soil just beneath the mulch. The moment the top of this firm soil becomes in the least dry there is immediately a process of depositing of salts and other matter between these particles of soil closing the pores and consequently diminishing the quantity of air that should freely pass through this soil to the roots. This condition not only points to the fact that you are allowing the air to be shut out but that you are losing moisture by evaporation from the soil which may be checked by cultivation. In fact, there should be no dry soil above your moisture except what is loose and fine. See to this point at all times. Note our explanation on this subject under Growing Trees.

Our article on percolation should be of interest to the irrigator as it indicates under what condition he can most economically apply his water.

The articles on Evaporation and Capillary Attraction should likewise be studied. Sub-irrigation is being practiced with marvelous results in some instances. It simply illustrates the importance of keeping the soil above the roots simply moist but in condition to admit of a free circulation

of air. The same condition practically is maintained when we store the rain waters in the soil or waters from irrigation ditches and allow it to percolate down deeply, then hold the water below by the mulch. Irrigation scientifically applied by the Campbell method will accomplish marvelous results.

REVIEW OF THE CAMPBELL METHOD.

OMAHA, NEB., Jan. 29, 1902.

Prof. H. W. Campbell, Holdrege, Neb.

DEAR SIR:—I take pleasure in contributing to your volume on Soil Culture my sincere testimonial in behalf of the work you have done, and the valuable results attained which justify the prediction that at no distant period agriculture and horticulture will prosper on the great semi-arid plains of the west, and millions of acres of fertile lands, lacking now nothing but the application of your method of cultivation, will become productive farms.

Since the spring of 1898 I have taken great interest in your experiments in the field, and visited in that year and the following year, several times, your farm in Cheyenne County, Kansas, and later your Model Farm in Graham County, in the same state, for the special purpose of studying your soil physics, and gaining as full a comprehension of your system of soil culture as possible.

I began my observations and study at the outset with a lack of faith, full of doubts and criticisms, and struggled along for some time against the conversion which came later and completely removed every ground of disbelief that had previously established itself in my mind. I had doubted, at first, whether the texture and formation of the soils found in the dry prairies were such that the upward movement of moisture from the reservoirs of water stored below the surface by your method of cultivation, would be sufficiently rapid, at the critical junctures that continued drought brings, to supply the field crops with the quantity of moisture absolutely needed to sustain growth and carry them over an extremely dry season. I am glad, however, to testify that my study and observation of the facts respecting this vital question, under such circumstances and conditions, both at Bird City and in Graham County, as made an extreme test of your system, proved to my mind conclusively that the capillary movement is ample in the severest drought, and that the only thing required is the conservation in the soil strata below of a quantity of moisture sufficient to carry the crop through the drought period: and that the problem of con-

L. of C.

serving a sufficient quantity of water is easily solved by early discing and subsequent plowing and sub-packing at the right time, and following the details of your method of cultivation, so that the entire season's rainfall may be stored and conserved for use to sustain and nourish the growing crop during the summer months.

With these two problems solved to my satisfaction, as they certainly were under the adverse conditions of two very dry seasons, I became an enthusiastic believer in, and advocate of, the Campbell Method of Soil Culture. Practically and substantially, with these questions settled, all doubt as to the reliability and value of your system of cultivation was removed and it became then a clear and plain matter to my mind that the saving of the rain waters by means of the soil mulch kept in active service by frequent stirring (according to your plan) and the percolation down into the storage reservoir below where they are held for the season's use, extraordinary crops may be grown every year.

My familiarity with nearly every section of the western portion of Nebraska and Kansas, and the eastern part of Colorado, leads me to the firmest belief that what you have done in Cheyenne and Graham Counties, in Kansas, can be done in all those adjacent sections where precisely the same condition of soil, rainfall, and climate prevails as in Cheyenne County, especially, and very nearly the same as are found in Graham County.

In tree growing you have accomplished results that are almost incredible to anyone who has not actually made the measurements of root growth and the growth of the trees made in your orchard in a single season, and satisfied himself of the success in that work that can be wrought by the practice of your system. I do not think I exaggerate when I say that your tree growths and orchard conditions, attained by your system of cultivation, aided by the soil mulch as taught by you, are as surprising and valuable as any that I have ever seen under irrigation in Southern California, where I have been a frequent visitor. I believe that before you have lived the allotted span of three score and ten years, you will be rejoiced as you shall look upon the measureless magnitude of a transformation wrought by your brain and your hand, by which a territory nearly as large as the continent of Europe, except Russia, and now treeless, bleak and unsheltered, will teem with woodland groves, magnificent harvest fields, fruitful orchards and gardens, among which the spires of numberless villages, churches, schools, and thousands of happy homes may be seen, all comprising and maintaining a vast aggregation of intelligent and prosperous people.

We are glad to do you honor and bid you God speed in this great work which is of inestimable value to your race.

Yours truly,

C. A. PARKS.

TO THE BOYS AND GIRLS ON THE FARM.

We cannot close these chapters without a few words of friendly counsel to the boys and girls on the farm.

Don't leave the farm. Stay on the old farm homestead, where you were born. It is the best home on earth.

Don't try to get away from nature, but get nearer to her if possible.

Drink her pure waters; eat her unadulterated foods, and breathe her sweet, pure air. These will combine to give you, and continue to give you, the rosy faces you wear, the buoyant, hopeful hearts that beat in your breasts, and the innocence and honesty that protect your lives from evil.

Remember that George Washington was a farmer and was proud of his calling, that, also, of the splendid galaxy of our great men whose distinguished talents were devoted to the service of their country as statesmen or presidents, since Washington's time, and whose fame is the greatest of all the nation's sons, the most of them were farmers, or joined agriculture with their public service or their professional pursuits. Daniel Webster, New England's greatest lawyer and statesman, was a farmer, and often left the Senate or Cabinet and returned to his farm on the quiet shore of Marshfield to follow the plow behind his favorite oxen.

He often said that he might frequently be found elsewhere but his heart could always be found at Marshfield. We have never met a great mind that did not love the land and long to settle down on some spot of ample acres where he could drink in the ambrosial delights of fields, meadows, and pastures with herds and flocks. Do not, my young friends, doubt, that to be an intelligent, progressive farmer is a higher vocation than any profession you can choose.

No matter how far you have pursued learning, or to what degree of refinement and elegance your accomplishments have reached, you will need them all to take first rank as a farmer. Chemistry, physics, and astronomy are the present necessary equipment for the leaders in the science of successful farming; and languages and the classics are a substantial aid to enable you to become counselors and instructors, and capable to teach others who are ambitious to learn to be first-class tillers of the soil.

Do not look down on farming, as a business, or permit anyone to disparage it in your presence without just rebuke, for it is far superior to the business of the tradesmen, or the "middle men," so-called, in any capacity, the latter of whom, especially, live like the scavenger sparrows, on "pickings."

Do not measure the importance and consequence of a business by

the fact that it can be carried on by men dressed up, whose hands are kept clean and soft, and whose faces are delicately pale and generally emaciated: pale and thin, very likely, for want of strong lungs and fresh, pure air and the lack of a good stomach and a corresponding appetite and an abundance of wholesome food, such as you always have on the farm.

Do not deceive yourselves by the delusive fancy that to live in the city where you will never get acquainted with your neighbors, and where the only amusement or recreation you can enjoy outside four stuffy walls, except you plank down one or two hard-earned dollars for a ticket to something, is to walk up and down miles of streets and look into show windows, fixed up to trap the unwary passers into buying something they don't need, is a better and happier abode than a good, comfortable farm home with a smokeless sky overhead and clean dirt underneath, and water to drink which is not pumped from a drainage canal, and with fine horses, and fat steers, and swine to look at, when at leisure, instead of the "jim cracks" of a jewelry shop, or the unmentionable and useless finery and things of other shops hung out by the city merchants to tempt you to purchase.

Think over the ways of the great city and then forever afterwards avoid it.

Not that we would advise you never to visit a city. No. Once a year, or, perhaps, less frequently, it may be well to cautiously enter its gates and breathe for a day the coal soot and brimstone loaded atmosphere of the metropolis. To take a peep into some of the dark holes, or stores, or trade marts, where bustling men and women are toiling and struggling, many to make just a little less than living wages, and some others, grunting and sweating to beat and push away their rivals and amass what they deem a fortune, utterly ignoring the divine teaching, "What shall it profit a man to gain the whole world and lose his own soul."

Visit for an hour the levee, so-called, a place known in some cities as "Hell's six acres," but be sure and take a stalwart policeman along. It is well to go there to get a glimpse of the unutterable poverty, misery, and sin, and the uncleanliness and degregation that human life can endure and for a time survive; then you should note how near to this festering swarm of human rottenness and woe the grand avenues and boulevards run, where the palaces of men who are gorged with accumulated riches stand as monuments of their success, at winning victories, by cunning and avarice, and largely by accident, over their fellow-men.

We would advise also, that you look at the reverse side of the great city, for there is a reverse side. Sodom and Gomorah had their temples of art, and these were, in their time, worthy of an occasional visit.

You should look into the museums and galleries and attend one or more of the grand concerts to catch a little of the inspiration that comes from the performances of great artists. Do not fail to look into the public libraries and book stores, the latter to select a number of volumes

to add to your home collection; for books are cheap, and are the best friends and companions that we can have. They are especially more valuable and beloved by you in your farm homes where you have leisure in the long winter evenings and in rainy weather, and at odds and ends of hours between your labors, to hold refreshing communion with them.

One night spent in the great city at the time of your annual visit will be enough. The "chink, chunk, and whiz" of the street cars, and the blowing of what will seem a million whistles, and the dashing oaths and grim yells and groans of the wide open nocturnal metropolitan life, and the fierce glare all night long of the electric light into your little seven by nine, two dollar per diem city bedroom, where you can sleep "nary a wink," will quench for a time your thirst for the fatiguing jars of the great city, and you will return home in a splendid spirit to enjoy your free, healthful, natural, and independent life on the farm.

Any young man can average to make a larger annual income in a period of five years on a farm than he can earn in the better grade of salaried positions in the city. The portion of that income which he can save in the country for a bank account or for investment, is more than twice the amount he could lay by if he lived in the city.

The temptations to the young in the city to waste earnings at places of amusement and in the purchase of many things that are of no useful purpose, and the constant menace there of the most powerful of the devil's allies, the saloon—which holds its jaws of death open night and day to swallow you up, and the immoralities, and other dangers there, should extinguish within you every desire to move from the country to the city. We say to the young men and young women who live on the farms of our bountiful west, write "excelsior" on your escutcheons, and look up with love and admiration to the noblest vocation given to man on this earth, agriculture, and resolve that you will cling to it and follow it through life. "Husbandman," "yeoman," the sole and exclusive qualification of a Roman citizen, and the mark of greatest distinction for any man in that time of superb civilization and learning, when the proud "Mistress of the World" by her Cæsars declared that husbandry alone qualified a Roman to exercise the franchise of citizenship.

Our appeal to you is to resolve to continue to be farmers. Buy land and improve it and increase your fortune by its enhanced value which is sure to come.

Educate yourselves in the knowledge and art of creating ideal farm homes. Bring to your use the improved and labor saving tools and utensils that have rendered it so much easier to perform the labor on the farm. Buy good books as your means will permit to give your wife and children the advantages of reading and culture. Give time and interest to the country social life which contributes so much to the enjoyment of all members of the neighborhood; above all, cultivate in the rural community where

you live the Christian spirit of cheerfulness and helpfulness among your people.

You will, I doubt not, come to believe that a country home; the farm; the old homestead; the trees and the orchard; the familiar fields and the cool, shady spots in the heat of the summer; the comfortable rooms and corners in the old farm house; the well-thumbed books; the children that will come to bless your hearts, all ruddy with the health of the country life; these, and a thousand other things, with sweet remembrances and happy sentiments will make your farm home far dearer to you than piles of brick and stone and dark rooms in the great city, can ever be to a true heart and a healthy mind.

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Largest Variety of Pumping Machinery Especially Adapted to

IRRIGATION

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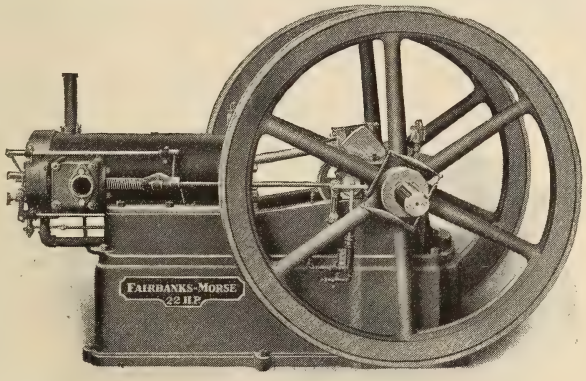

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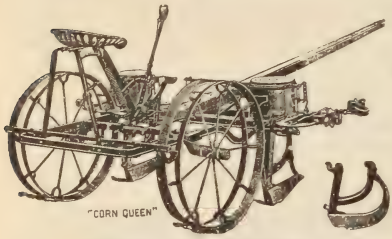

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A most **Accurate, Certain, Very Strong** and very **Best Equipped** Planter made. A machine that will be doing perfect work years after others are worn out.

COLUMBUS, MD., March 15th 1901.

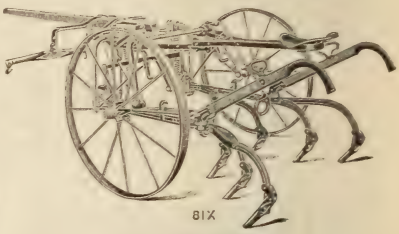
AVERY MFG. CO.,

Peoria, Ills.

DEAR SIRS:—I wish to say to whom it may concern that I have used different cultivators, but none of them ever did the work like the VACUNA. Any person can handle it with ease and it works like a clock. I work it on hillsides and rough land and it works to perfection. Any person can work it that can drive a team of horses, it makes no difference. I drove to where the corn row stopped; from thereon it was sodded ground and I ploughed right through this ground.

Yours truly,

DANIEL WAGNER.



THE VACUNA.

Greatest of combined Cultivators, and one of **Six** distinct types of Cultivators we build with not a poor one in the lot. **Furnished** with any style gangs, **Eagle Claws, Spring Tooth Gopher, Spring Trips,** Etc.

MILFORD, NEB., April 12, 1901.

AVERY MFG. CO.,

Peoria, Ill.

GENTLEMEN: Your favor of the 9th of April at hand, asking if I have bought any machinery elsewhere, and I reply herewith that I have not bought yet, but I will buy a riding cultivator of Mr. Paul Herpolsheimer. *I would not buy any other kind than the Avery* for I know by experience they are far the best.

We are using three Avery Cultivators, and we have an Avery Stalk Cutter and a Corn Planter. I think they can't be beat.

Respectfully yours,

MARTIN WILLERS.

The BEST machinery costs but little more than common kinds. It will pay you to investigate our line, which also includes **WAGONS, STALK CUTTERS, ENGINES, THRESHERS, ETC.** Our handsome Catalogue FREE.

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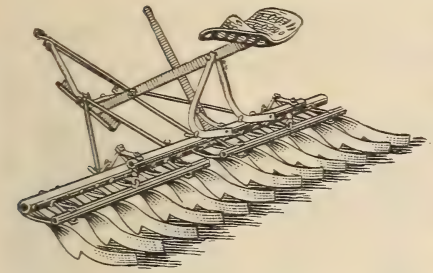
ESTABLISHED 1872.

We offer full line of Nursery Stock carefully grown for, and adapted to the semi-arid West. The remarkable success of our large branch Commercial Orchards in Western Nebraska clearly shows that our trees are adapted to Western conditions. In the Daniel Hunter orchard, 317 miles west of Omaha, apple trees planted in 1897 yielded one and three-fourths bushels per tree in 1901. Peach trees planted same season yielded two bushels per tree.

We grow for and send out to our customers the same varieties which have proven successful for us. We do not winter our trees in cellars. Trees and plants in possession of full vigor, are packed with such care as to reach customers in condition to grow.

We supplied the Pomeroy station with the trees so successfully planted in 1900-1901. We yet hold the record of growing the largest number of bushels of apples in one season of any orchard in Nebraska. Correspondence desired. Satisfaction guaranteed. ADDRESS.

E. F. STEPHENS, Mgr. ...CRETE, NEB.



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Pulverizing Harrow, Clod Crusher and Leveler

SENT ON TRIAL, to be Returned at my Expense if not Satisfactory.

I deliver free on board at Kansas City, Chicago, Columbus, Louisville, New York, Minneapolis, San Francisco, etc. **Sizes 3 to 13½ Feet.** The best pulverizer and cheapest **Riding Harrow** on earth. We also make walking **Acmes.** The **Acme** crushes, cuts, pulverizes, turns and levels all soils for all purposes. Made entirely of cast steel and wrought iron—**indestructible.** The **Acme** is highly recommended by Mr. Campbell, and has "stood by" him in all of his experiments. Catalog and booklet, "An Ideal Harrow," by Henry Stewart, mailed free.

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REAL ESTATE bought sold, and rented. Taxes paid for non-residents. FARM LOANS.
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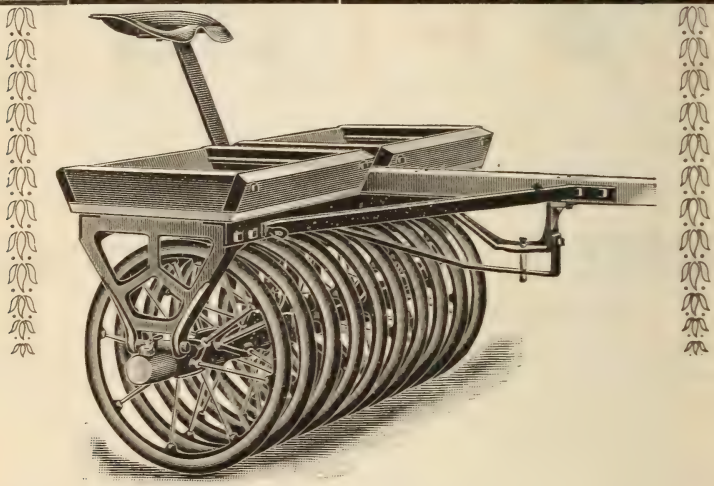

This is the Sub-Surface Packer that does pulverize and pack the lower portion of deed plowing and leave the top loose.

If you want to get a good and sure stand of ALFALFA with one-half the seed usually sown, get a SUB-SURFACE PACKER.

Prof. Cottrell, of the Kansas Agricultural College, in a recent communication, said:

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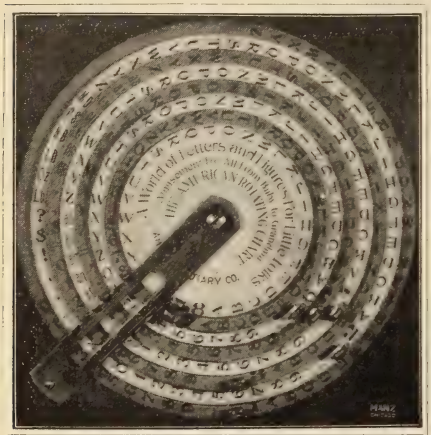

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